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FEBRUARY, 1918

CONTENTS

The Valley of Ten Thousand Smokes:
National Geographic Society Explorations in the Katmai District of Alaska
47 Illustrations — ROBERT F. GRIGGS

Helping to Solve Our Allies' Food Problem
23 Illustrations — RALPH GRAVES

Billions of Barrels of Oil Locked Up in Rocks
10 Illustrations — GUY ELLIOTT MITCHELL

Shopping Abroad for Our Army in France
6 Illustrations — HERBERT COREY

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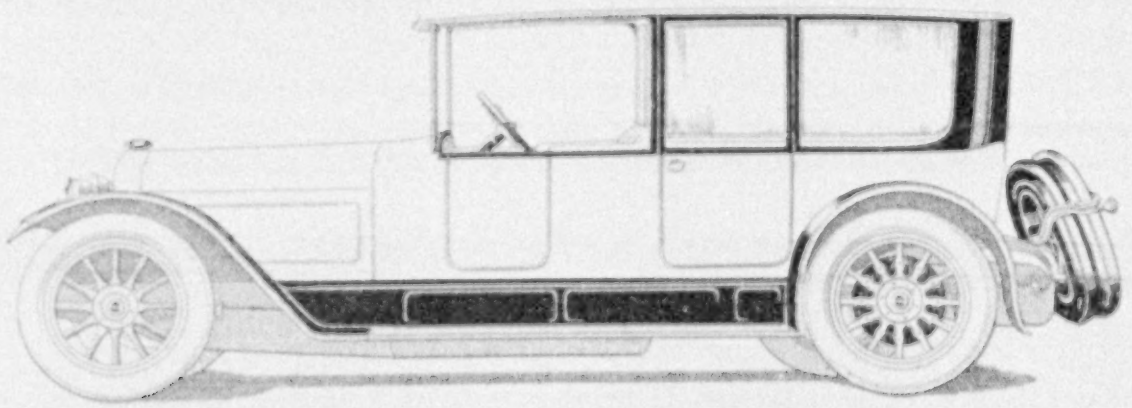

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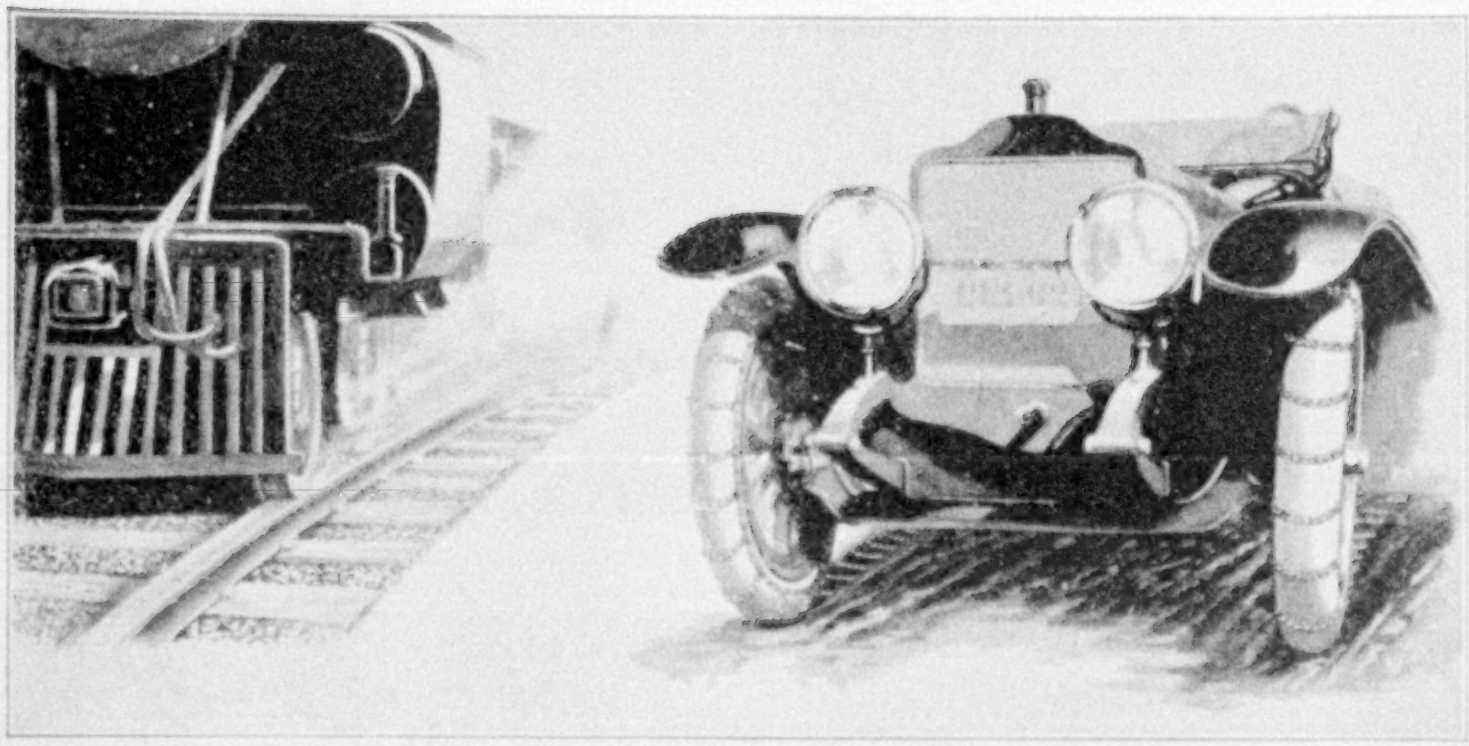

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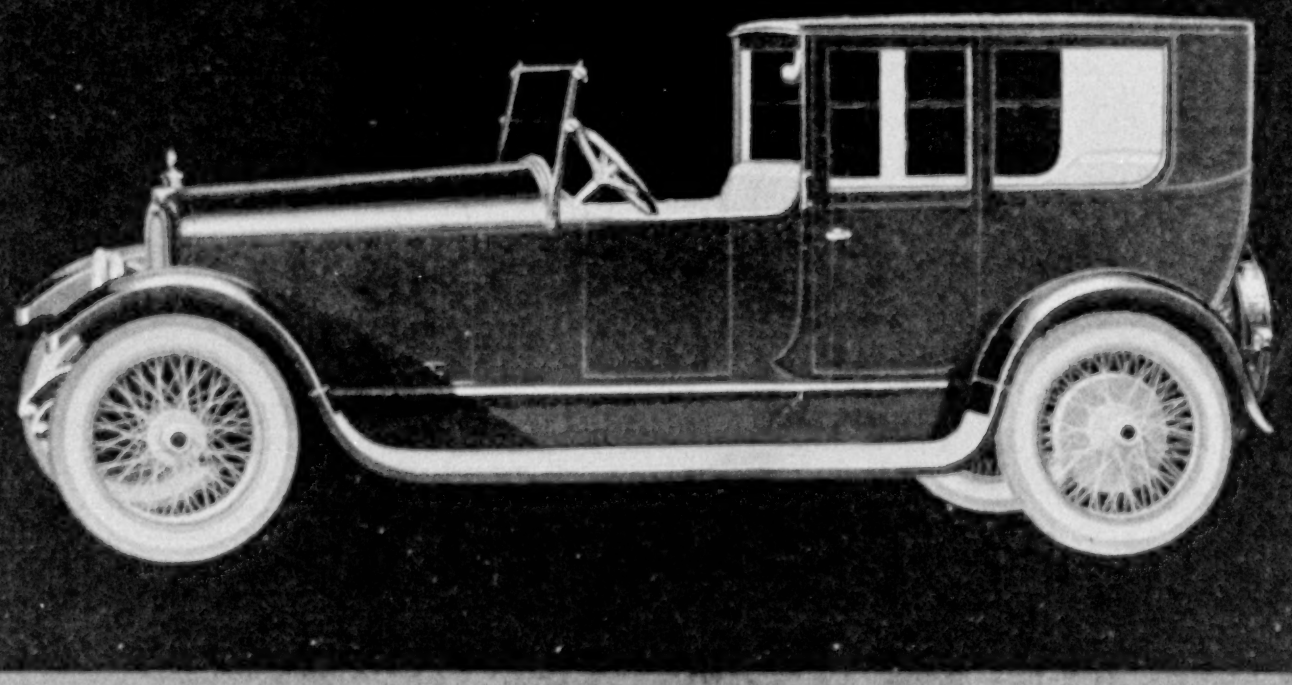

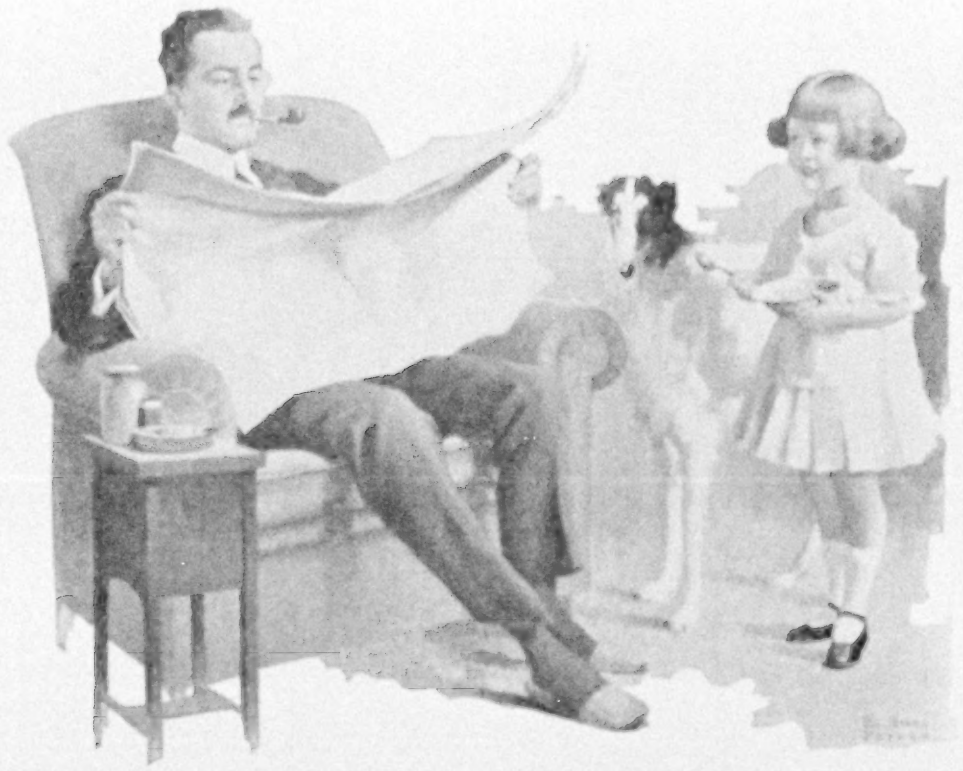

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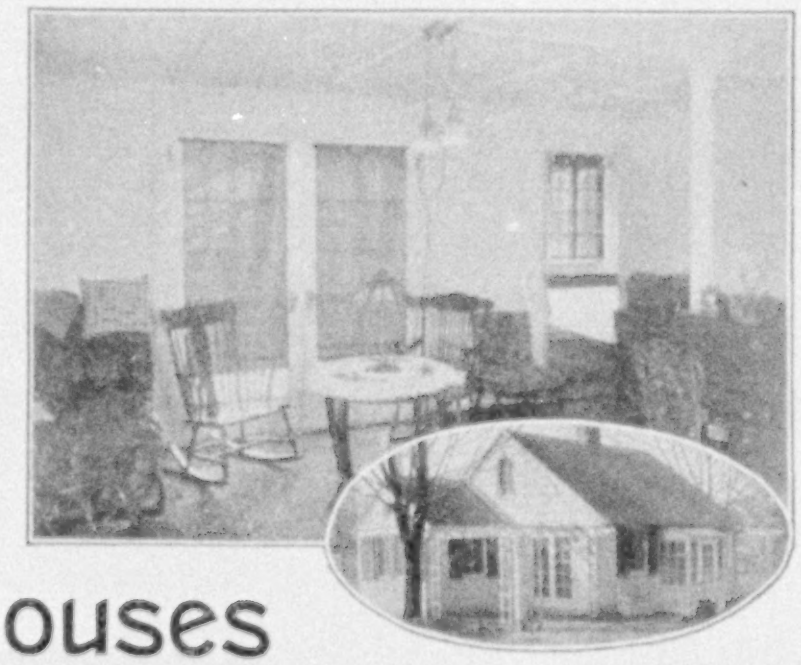

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From a photograph by Robert F. Griggs

THE AWE-I

From the floor of this vast val
their tread, Robert F. Griggs, leade
studying the geology of this most an
of the tremendous magnitude, even o
of the members of the expedition is

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AWE-INSPIRING SPECTACLE OF THE VALLEY OF TEN THOUSAND SMOKES, DISCOVERE

s vast valley in Alaska several million jets of steam seethe and hiss—sibilant tongues telling the story of the hell's caldron o
gs, leader of the Society's Expedition of 1917, and the members of his party made their way, back and forth, plunging throu
s most amazing example of her processes which Nature has revealed to twentieth-century man—one of Vulcan's melting-pots fr
le, even of this small portion, for it hardly seems credible that a distance of two miles separates the tent in the right foregrou
edition is seen standing, was the natural stove used by the party in cooking all of their meals while encamped on the edge of

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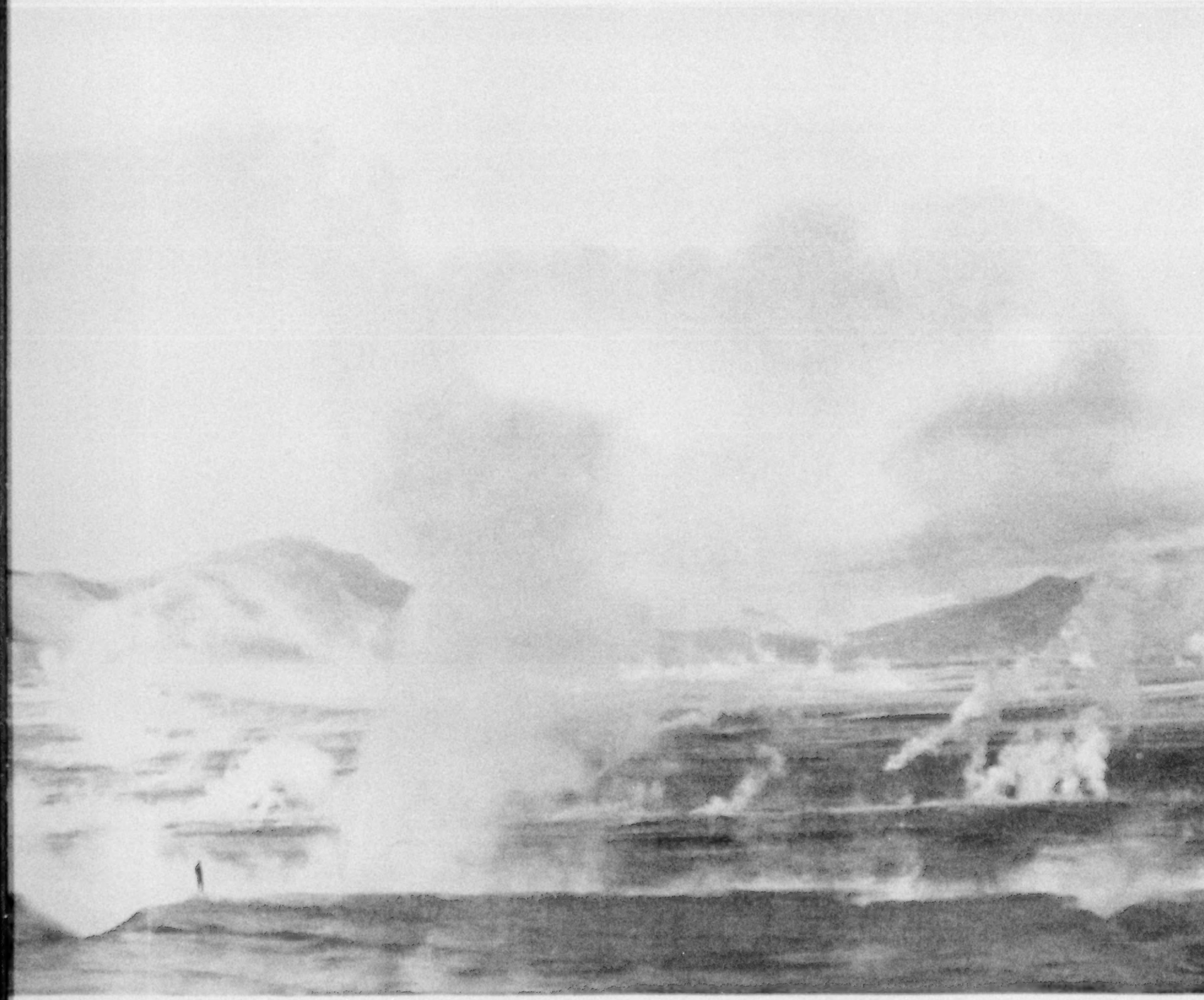

SMOKES, DISCOVERED AND EXPLORED BY NATIONAL GEOGRAPHIC SOCIETY EXPEDITIONS

e story of the hell's caldron of volcanic heat which lies beneath the surface. Over this thin crust of hot, treacherous earth, w back and forth, plunging through the suffocating vapors, trapping gases for chemical analysis, making soundings, mapping the ne of Vulcan's melting-pots from which the world is created. Only about one-fifth of the valley is shown here; but it is difficult the tent in the right foreground from the cloud of white steam immediately above it. The V-shaped crevasse in the central fore hile encamped on the edge of this the First Wonder of the World.

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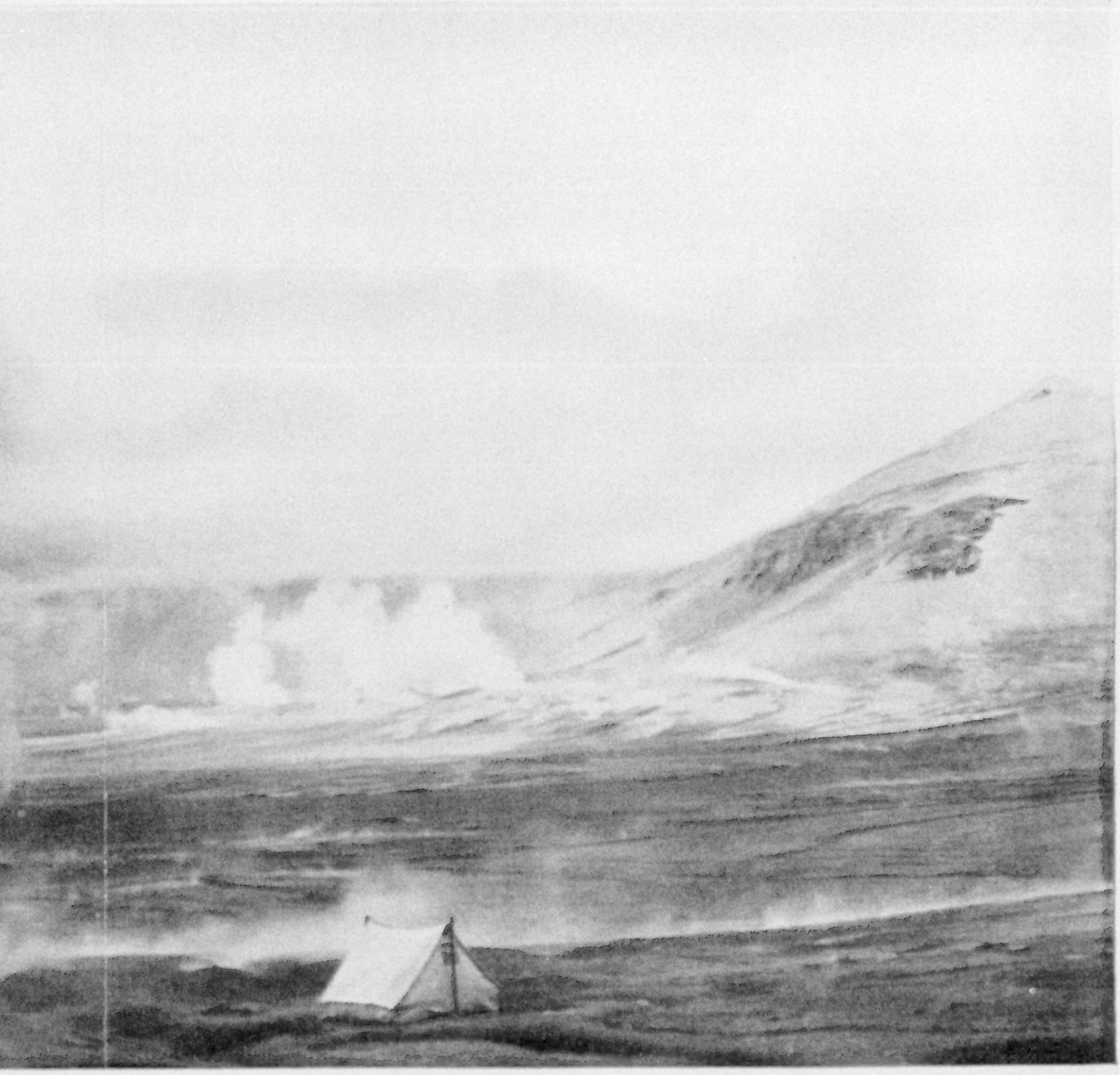

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earth, which often broke beneath
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VOL. XXXIII, No. 2 WASHINGTON FEBRUARY, 1918

THE NATIONAL GEOGRAPHIC MAGAZINE

THE VALLEY OF TEN THOUSAND SMOKES

An Account of the Discovery and Exploration of the Most Wonderful Volcanic Region in the World

By Robert F. Griggs

Director of the National Geographic Society Katmai Expeditions of 1915, 1916, and 1917

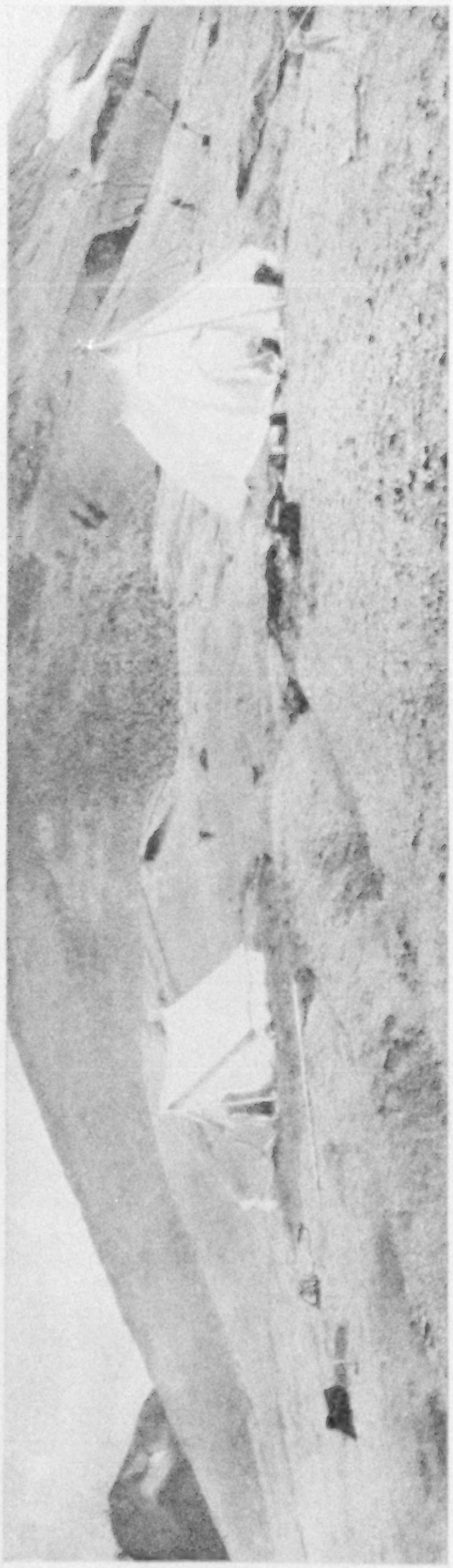
Having achieved the distinction of being the first explorer to ascend Mt. Katmai and study its active crater, the largest in the world, Mr. Griggs, in the Geographic *for January, 1917, gave a detailed account of the region in Alaska affected by the explosion of this mountain, which was one of the most tremendous volcanic eruptions since the beginning of recorded history. In the present article he makes known to the members of the Society the wonders of the gigantic safety-valve area adjacent to Mt. Katmai, which he has named the Valley of Ten Thousand Smokes, discovered and explored by National Geographic Society expeditions.*

WHEN the members of the Katmai Expedition of the National Geographic Society, looking through Katmai Pass, first beheld below them the Valley of Ten Thousand Smokes, it was at once evident that one of the great wonders of the world had been discovered. The first glance was enough to demonstrate that we had found a miracle of nature which, when known, would be ranked with the Yellowstone, the Grand Canyon, and other marvels, each standing without rival in its own class (see also pages 131 and 147).

But in spite of the certainty which possessed us of the magnitude and importance of our discovery, further investigation at that time was impossible. We had been equipped for the definite task of exploring Katmai and reaching the crater of the gigantic volcano from which had come the tremendous eruption of June 6, 1912, one of the most violent in history.

For the accomplishment of this purpose our outfit had proved adequate. But the equipment was entirely insufficient to permit us to extend our lines across to the Bering Sea side of the range and maintain a camp in the Valley of Ten Thousand Smokes. Moreover, the time remaining to us was too short for the task, even if we had been adequately equipped.

As recounted in the Geographic for January, 1917, we were compelled, therefore, to turn back, with only the scantiest evidence to substantiate the story of our truly remarkable discovery. However,



Photograph by Clarence F. Maynard

STEAM-HEATED TENTS AT THE HEAD OF THE VALLEY OF TEN THOUSAND SMOKES

"When we turned in the first night we were astonished to find that the ground under our tent was decidedly warm. On examination we found that a thermometer thrust six inches into the ground promptly rose to the boiling point. This was indeed a surprise, for the place had been only recently vacated by the retreating snowbank behind us. We put most of our bedding under us to keep us cool!"

through the generosity of the Board of Managers of the National Geographic Society, funds for another expedition were provided, and during the summer months of 1917 we were able to continue the explorations of the previous year.*

THE TEN THOUSAND SMOKES A VAST SAFETY-VALVE

When we reached Katmai Pass, in June, 1917, I saw at once that everything was just as it had been the previous year. There were the two little fumaroles which we had first found, steaming away exactly as they had been the year before. This was decidedly reassuring, for I had been tormented with the fear that after all the time and effort spent in preparation for the expedition I might find that we had seen only a passing stage in the declining activity, and when we arrived we would find the valley dead, with all its volcanoes a thing of the past.

When I got back to camp and reported the conditions, I found that some other members of the party had been secretly entertaining the opposite fear—that the whole valley was likely to blow up suddenly while we were in it!

On the contrary, all that we have seen indicates that the activity of this district, like that of the Yellowstone Park, has reached a stable stage, which will continue without much change for a relatively long

* This was the fourth expedition sent by the National Geographic Society to investigate the stupendous eruption of Mt. Katmai. The first was in 1912, led by George C. Martin, of the U. S. Geological Survey, Mr. Martin's report, with 57 illustrations, being printed in the February, 1913, number; the second was in 1915 and the third in 1916, both directed by Robert F. Griggs, of the Ohio State University, whose report was printed in the January, 1917, number of the NATIONAL GEOGRAPHIC MAGAZINE, with 52 illustrations. To appreciate the number and magnitude of the discoveries made by the National Geographic Society expeditions, members should read again these reports. Extra copies of these interesting numbers may be obtained at 25 cents each.

period. Wherever we went conditions were the same. All the vents, big and little, are remarkably constant in their activity.

As long as steam continues to escape in such quantities, there appears to be little probability of a recurrence of any violent explosions like those of 1912, for the present activity of the region acts as a safety-valve to relieve the pressure from below and prevent its reaching the danger point.

FIRST VIEW OF THE TEN THOUSAND SMOKES

Last year Walter, who had been keeping camp the day we discovered the valley, had listened to our accounts of its wonders with polite incredulity. I was interested to see what the effect of really seeing the valley might be on an uneducated native with no scientific interest to spur him on.

When we had examined the little fumaroles in the pass and looked at the dozen or so of others round about, he turned to me with an air of "Well, I thought so all the time," and asked, "And is this the Valley of Ten Thousand Smokes?" "Oh! No," I answered; "that is over the rise yonder."

When we reached a point where we could see on down the valley, his amazement was unbounded. "Why," he exclaimed, "a whole big valley all full of smoke!"

I had planned merely to look in and turn back, for we had come a long way—so far that he had frequently remarked on the way up how far we had come and how fast I was walking, and had even asked to rest. But once he caught sight of the valley, he must go on. It was my time to call halt now, for I was thinking of the long way back to camp. But before I could stop him he had gone a couple of miles beyond the pass. He came home with shining eyes, very much excited, and though he was very tired he kept talking to Andrean about the wonder he had seen until late into the night.

How I wished I could have understood his Russian and heard exactly what sort of an impression the valley had made. I am sure his description must have been far more picturesque than anything I could write.

A WONDERFUL AND AMAZING SIGHT

It was indeed a wonderful and amazing sight that we looked upon, as we came into the valley from between the two lava mountains which guard the entrance. Nor had this marvel of nature lost any of its allurement in the interval that had passed since the one fleeting glimpse I had had of the phenomenon the year before.

As far as one could see down the broad flat-floored valley, great columns of white vapor were pouring out of the fissured ground and rising gracefully, until they mingled in a common cloud which hung between the mountain walls on either side. We could not see how far the activity extended, for about 5 miles down the valley the smoke had entirely closed in, cutting off any further view in that direction.

But we could look far up into the branches, which are given off to east and west from the head of the main valley. To the west the columns of steam could be seen coming out of the ground, close up to the base of the glaciers that wind down from the snowfields of Mt. Mageik, some four miles away. To the east our vision could not penetrate so far because of the prodigious activity in that quarter, where myriads of vents of all sizes were pouring forth immense quantities of smoke.

CROSSING THE MOUNTAINS AGAINST A HAIL OF PUMICE

It was four days later before all was in readiness for the whole party to go over. None of those who made that trip will ever forget it. The wind, which had been blowing uncomfortably hard for several days, freshened during the night until it began to carry away our dishes. The wind gauge in the sheltered nook we had selected for our camp showed a velocity of 25 miles per hour. Out on the mountain it was blowing twice as hard and directly in our faces. It was so strong as fairly to lift us off our feet at times; but worse than the wind itself was the hail of sharp pumice which it raised. The pumice cut like a knife whenever it struck our flesh. The others protected

Photograph by D. B. Church

SUNSET IN KATMAI PASS

The two little fumaroles to be seen at the right were the first of the millions of steam jets which the expedition discovered upon entering the majestic valley

their eyes with close-fitting goggles; but the leader could not avail himself of that relief because of the necessity of keeping to the trail, which in places was completely drifted over. Fortunately this lasted only round the shoulder of Observation Mountain, and from there on the going was comparatively easy.

We later found, however, that this was by no means an extreme wind for this region. On another occasion the men, after starting, were unable to make it and had to turn back. The wind gauge at the sheltered camp that day registered 60 miles an hour steadily, and much higher on the gusts.

MILLIONS OF VOLCANIC VENTS

When this year's party reached the valley, the effect on the men was stupendous. None had imagined anything nearly so wonderful. Every one agreed that no description could convey any conception of its immensity or grandeur.

I found that my matter-of-fact chemist was counting the smokes to see whether I had been justified in asserting that there were ten thousand of them. He soon announced that I was quite well inside the number. There are certainly many times ten thousand to be seen, even on a clear day, and when the weather is moist myriads more appear, for then the smoke from the millions of little holes whose gases ordinarily are invisible condense until there are a thousand times ten thousand.

One member of the party, who having traveled considerably and found many of the sights of the world overdrawn, was somewhat skeptical in advance about the Ten Thousand Smokes. When once he felt its thrall, however, he repeated over and over again, "Why, you couldn't exaggerate it." This statement is perfectly true. While the statistics of length, area, etc., could be falsified, the enlarged figures could no more convey any idea of the immensity of the new wonderland than can the real dimensions.

This is one of the greatest wonders of the world, if not indeed the very greatest of all the wonders on the face of the earth. The valley cannot be described; only after one has spent many days within its confines does one begin to grasp the proportions. All of these comments were made on first sight. We had not yet really seen the valley ourselves.

OVERAWED BY THE WONDERFUL VALLEY

The sensation of wonder and admiration, which came first to all, soon gave way to one of stupefaction. The magnitude of the phenomena simply overcame us. As we moved to any corner of the valley, what we had supposed from a distance to be little fumaroles turned out monster vents, each group more wonderful a spectacle than the whole, seen in panorama, so inconceivably vast is the volcanic region.

No amount of experience seemed sufficient to enable us to grasp proportions of this enormous safety-valve.

For the first few days we were overawed. For a while we simply could not think or act in the ordinary way. At night I would curse myself, as I lay in my blankets, and make a list of the things I wanted to do the next day; but when the morning came I could not move myself to action. I could only look and gape.

Shipley, the chemist, was easily the most self-possessed of the crowd. But for him we probably would have turned around and come home without any of the scientific material we had gone to collect. After all, the whole valley is very much of a gigantic chemical laboratory, and perhaps that accounts for his greater command of himself. Yet on the third day he remarked that "he did not feel like monkeying with his little bottles of chemicals."

X— was frankly scared to death. He did what I told him, but except when told to do something he sat in a dull-eyed stupor, like one at the funeral of his sweetheart, from which no efforts of ours could rouse him. I can only guess the effort it must have cost him to go up to the fumaroles and get pictures of them. He said himself that he expected to go crazy before he got out again. He had to be relieved and sent down to the lower camp before he regained his nerve, but in the end had as good command of himself as any of us.

XUM

Photograph by D. B. Church

PUTTING THE EXPEDITION'S SUPPER ON TO BOIL IN THE NATURAL STOVE OF THE VALLEY

There was no wood nearer than 15 miles from the camp at the head of the Valley of Ten Thousand Smokes, but the difficulties of cooking were solved by making use of one of the fumaroles from which steam constantly issued. It was possible to cook anything in this fireless cooker except fried bacon and flapjacks.

I was utterly unprepared for the feelings which thus overcame me. In 1916 I had not stayed long enough in the valley to get beyond the first sensations of wonder and admiration. I had by no means grasped the situation sufficiently to report it accurately. This region should have been named "The Valley of a Million Smokes," for there are certainly not one, but several millions of them all told.

FEAR OF CAVE-INS AND FUMES

A large factor in my feelings was plain fear. Perhaps I ought in honesty to say cowardice. The spectacle was so much bigger than I remembered it that I was badly scared by the job I had undertaken. The fear which beset me was twofold: fear of cave-ins and fear of the fumes.

As we explored the margin of the valley (the worst place, as we afterward found), we could plainly hear the ground ring hollow beneath the tunks of our staffs, and more than once we felt it shake beneath our blows. What if the ground should suddenly give way beneath our feet and precipitate us into a steaming caldron?

A breath of the steam from a vent blown around us for a moment by a chance breeze gave an uncomfortable burn. We knew that if once a man fell into such a place he would be instantly parboiled.

At first we roped up as for mountain-climbing and spread out, so that if one man went through, the others could pull him out. But when we came better to realize the conditions, we discarded the ropes, for we decided that if a man once got in it would be more merciful to leave him than to attempt to pull him out.

We had been assured by the best authority that there could be no danger from the fumes, but I had brought along a chemist partly for the express purpose of warning us as to what was not safe. I knew this valley to be different from every other place in the world, and reasoned that there could be no real basis for the assurances given me. What I feared was carbon monoxide, that colorless, odorless, tasteless gas, deadly even in concentrations as small as five parts in 10,000. It is usually present in the emanations from volcanoes. There is, moreover, no simple chemical test by which its presence may be detected. What if we should get a dose of that before we were aware of the danger?

But, like practically all the bugaboos which one meets in this world, these were proved by experience to be much less dangerous than our imaginations had pictured. Experience showed that there was always plenty of air to breathe, and we found no insidious gases likely to strike one down without warning, for our noses always gave us abundant notice of dangerous places, so that we suffered no injury beyond slight headaches and temporary inconvenience.

LEARNING TO TRAVEL SAFELY

So also with the cave-ins. As we grew familiar with the conditions we built up a basis of experience that soon enabled us to pick our way with some degree of safety. The deposits brought up by the fumaroles themselves so encrust their throats and the ground round about that a thin roof over a cavern will support a man with safety.

The worst places were those where fissures had been bridged over by ash and mud, so as to leave nothing to indicate their presence. After we had been in the valley several days we had some experiences with such places that probably would have turned us back had they occurred when we first arrived.

Several times, when we accidentally put a foot through a thin place in the crust, steam came spouting out of the hole, forming a new fumarole. But it was always one foot only and the owner did not take long to get out.

Once, while walking across a place that looked perfectly solid, I noticed a new hole midway between two old fissures and on investigating found that a steaming fissure two feet wide and ten feet deep was roofed over for fifty feet by a layer of mud so thin that I could perforate it anywhere by a slight thrust with my ice-ax.

But such experiences rapidly led us to perfect a sort of technique like that of the mountain-climber, which enabled us to choose the safest paths. Moreover,

Photograph by D. B. Church

WAITING FOR SUPPER ON THE EDGE OF THE STEAM OVEN

"As the pots were surrounded by an atmosphere of live steam, just at the point of condensing, nothing ever boiled away nor cooked to pieces, and no matter how long we forgot it, nothing ever burned. Everything was always done exactly right."

the first trip over the ground was the most dangerous. After one man had explored any area in safety, there was no probability of accident to those who followed.

COOKING AT A FUMAROLE

In many places the valley round about the vents is covered with a peculiar blue mud, thinly coated with a chestnut-brown crust, which sometimes supports one and sometimes gives way suddenly, letting one down to his shoe-tops in the soft, scalding mud beneath. At such times one is apt to feel that his feet are taking hold on hell in very verity, particularly if the place happens to look "ticklish" otherwise. We were surprised to find that continued immersion of our feet in such places did our shoes no perceptible injury, for we had expected that they would be rapidly eaten away.

We chose our camp well up on the mountain side overlooking the valley, close beside a melting snow-drift. Here, although we were denied the pleasure of a camp-fire, for not a stick of wood remains anywhere in the valley, we had "all the comforts of home." Fifty yards behind us was our refrigerator, where we could keep everything freezing cold until needed (see page 124).

Just in front was our cook-stove—a mild-mannered fumarole—into which we hung our pots to cook our food. We were somewhat dubious beforehand as to the feasibility of this method of cooking, because of the noxious gases that came off along with the steam; but the results were more than satisfactory. We never detected the faintest taint in any of our food. Everything was always done exactly right. Since the pots were surrounded by an atmosphere of live steam, just at the point of condensing, nothing ever boiled away, cooked to pieces, or burned, no matter how long neglected or forgotten.

There was only one drawback: while we were in the valley we had to do without our old standbys, bacon and flapjacks, for our stove would not fry. There were, however, many vents in the valley quite hot enough to fry bacon. The vapor from most of the more active ones is so hot that the steam does not condense for some distance beyond the vents (see page 133). When a stick is poked into these the end is quickly charred, indicating a temperature considerably above the frying point.

Our thermometers did not read high enough to measure the temperatures of these vents, so we were unable to ascertain exactly how hot they were. But we did not think it advisable to try bacon and flapjacks in them, because most of them are a little too vigorous to be altogether manageable. The vapor in many cases comes out with such force that the frying pan would have had to be held down against the rising steam. A sudden puff of wind from an unexpected quarter might, moreover, have blown the steam in the cook's face and inflicted a serious burn.

A STEAM-HEATED TENT

When we turned in the first night, we were astonished to find that the ground under our tent was decidedly warm. On examination we found that a thermometer thrust 6 inches into the ground promptly rose to the boiling point. This was indeed a surprise, for the place only recently had been vacated by the retreating snowbank behind us.

We put most of our bedding under us to keep us cool!

But before long our blankets were as hot as the ground. Close to the snow-drift as we were, and at an altitude of about 2,500 feet, the air was at times quite cold; so while we steamed on one side we froze on the other. We had to keep turning over and over in the effort to equalize the temperature. We did not sleep much the first night, and all expected to "catch our death of cold."

After a few hours we discovered that the ground was not merely hot, but that invisible vapors were everywhere seeping up through the soil. The condensation of this steam from the ground made our bedding first damp and then wet, so that by morning we were in a most curious case. The sensations that greeted us on awakening in these warm, wet beds can in justice be compared only with certain distressing memories of one's childhood days, which they exactly paralleled.

XUM

Photograph by Robert F. Griggs

OUR REFRIGERATOR

Just behind the tent was an ash-covered snow-drift that made an ideal refrigerator. The only trouble was that our larder was hardly equal to the accommodations afforded.

This state of affairs worried us very much indeed, for such conditions were the worst possible for the films on which we were depending to vouch for our story. By building a sort of crib with the walking sticks we had brought from the lower camp, we managed to keep them off the floor, and so reasonably cool; but in spite of all our efforts, they showed considerable deterioration before they could be developed.

Our instruments also took up water and swelled, so that we feared we should lose everything. A tripod, which had successfully stood the climate of a tropical-rain forest, jammed so hard that it could not be hammered loose. The cameras swelled until their focal points were shifted. A panoramic outfit upon which high hopes had been built refused to work and was altogether useless for the rest of the summer.

As I saw everything thus rapidly soaking up with water, I was very much disturbed over the consequences that would ensue when we should be caught in the rain; for, while our fumarole might be an ideal cook-stove, it was no good to dry clothes by. With a steamy tent there would be absolutely no way of drying our clothes after they were once wet. (Transportation was so difficult that we had brought no change of clothing.)

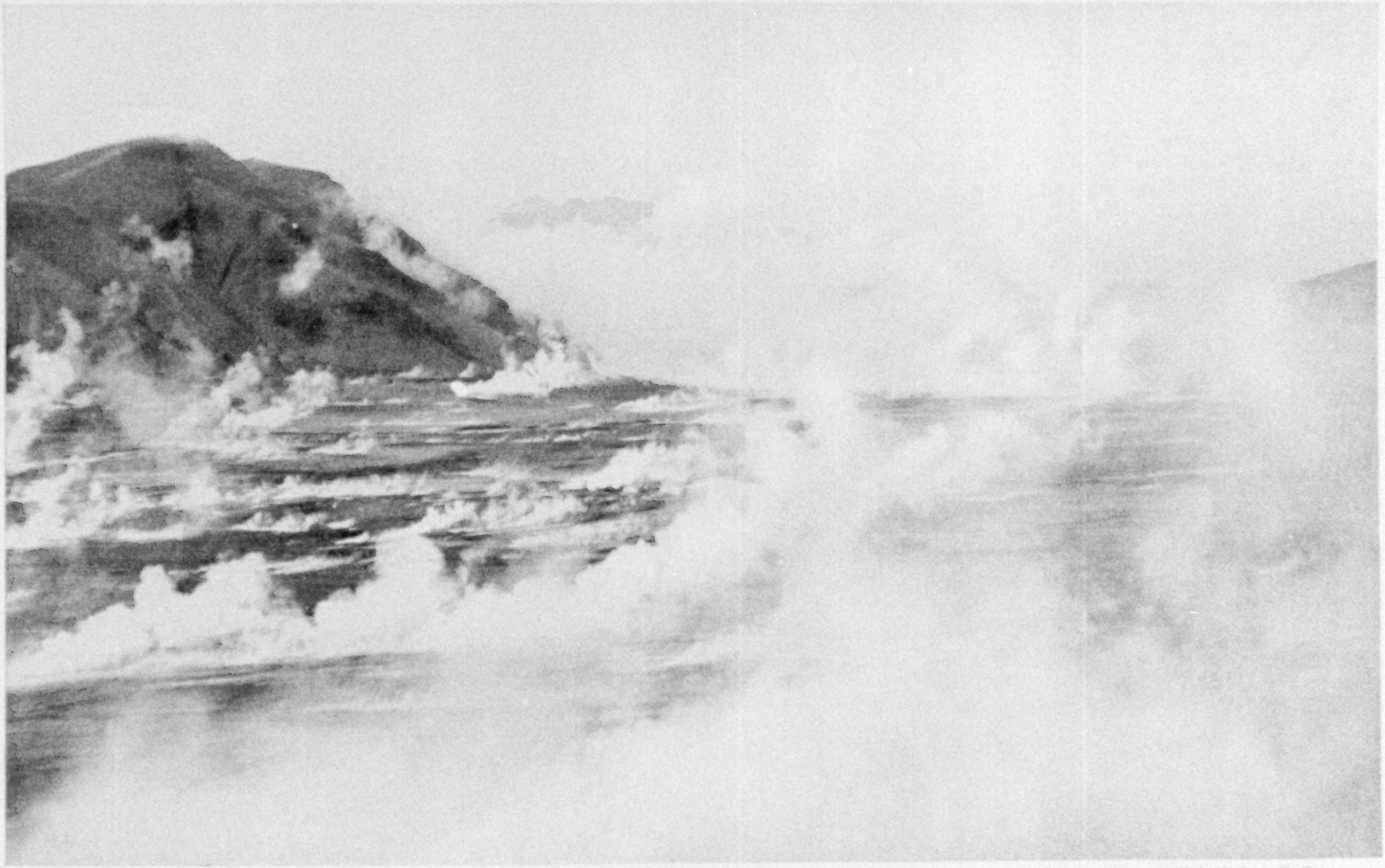
VAPORS OF THE VALLEY CURED RHEUMATISM

But in all these fears I was most happily disappointed, for we found that while everything soon became steamy damp in spite of all we could do, likewise anything that got sopping wet was soon reduced to the same moist condition. When we came in soaked through and chilled after a ducking, therefore, we found that the thing to do was to crawl into our blankets, and after a while both clothes and bedding would become as "dry" as when we started out.

Photograph by Robert F. Griggs

LOOKING ACROSS THE VALLEY FROM CAMP FIVE

The cloud of white steam issuing from the vent in the background is two miles distant



Photograph by Robert F. Griggs

A VIEW OF THE FIRST WONDER OF THE WORLD, FROM CAMP FIVE, AT THE ENTRANCE TO THE GREAT VALLEY, WITH ITS MILLIONS OF STEAM JETS ALWAYS IN ACTIVE OPERATION

The main valley is more than seventeen miles in length, but a complete view is never possible from any one vantage point, for so dense is the smoke that everything beyond five miles in any direction is hidden behind an impenetrable white pall

Photograph by Robert F. Griggs

STEAM COMING OUT ALONG THE LENGTH OF A FISSURE

"The marginal fissures usually stand open like great cracks in the surface, into which one might fall unless careful. If one tosses pebbles into the mouths of these vents they are so buoyed up by the rising gases that they are either immediately spewed out again or sink slowly down through the rising steam like feathers settling to earth" (see page 137).

In spite of the exposure to which we were daily subjected, there was not a sign of a cold or other illness in the party, but, on the contrary, the constant steaming seemed a good treatment for the rheumatic pains which usually develop on such expeditions. During our stay in the valley, and for some time after we left, we were as free from such aches as if we had taken the "cure" at a hot spring.

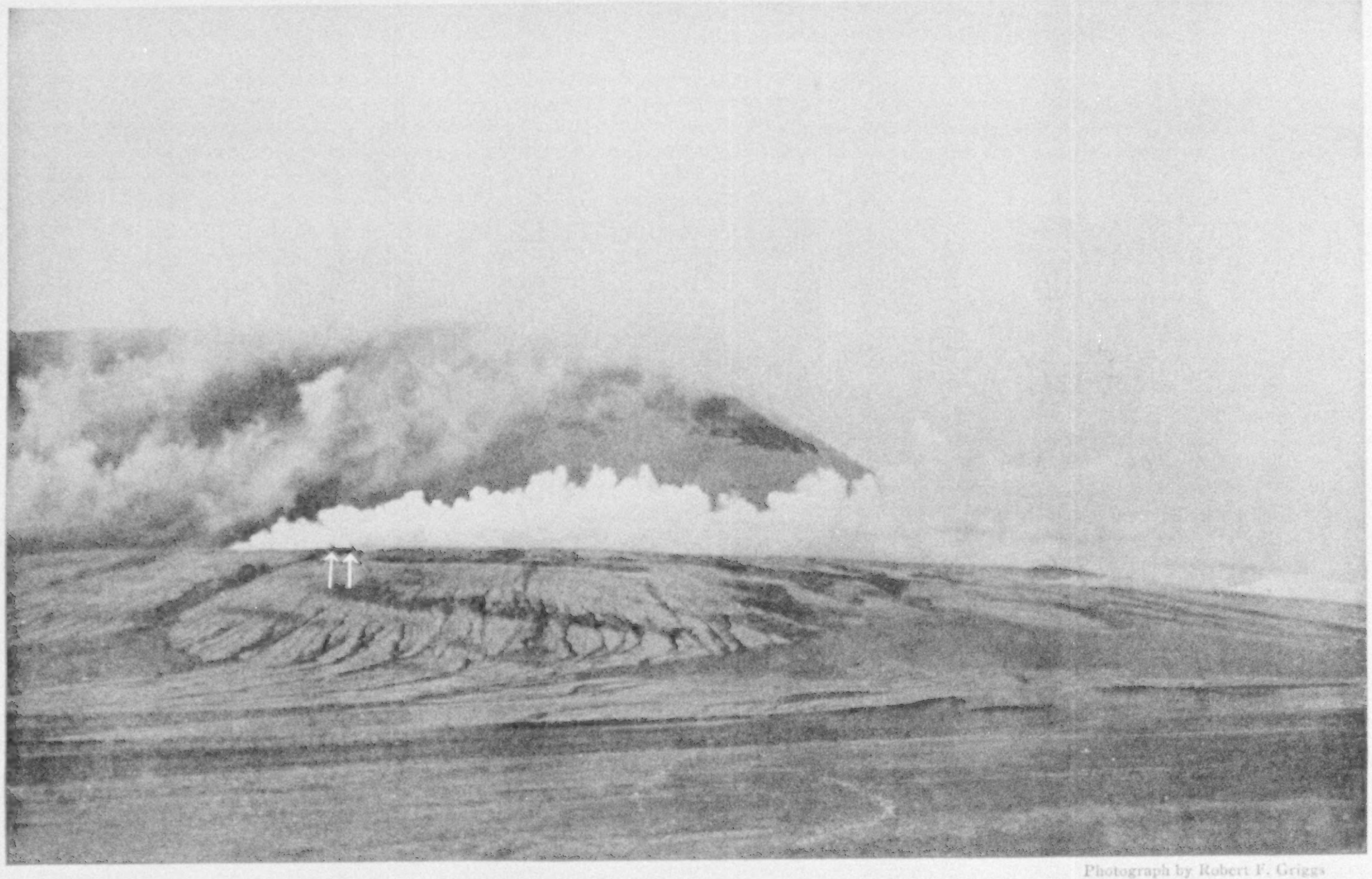
We came, therefore, to appreciate greatly our steam-heated tent, for we found it always warm and cozy, and there were times when the driving wind and rain outside were so bitter that we could hardly have endured the hardships otherwise.

THE WEATHER HAS MANY EVIL MOODS IN THE VALLEY

It would be a mistake, however, to suppose that with all our conveniences the conditions of our life in the valley were altogether ideal. The Alaska Peninsula is notorious as a storm-breeder, and before the eruption Katmai Pass had a reputation for bad weather not to be matched elsewhere on the American continent. Now, with such enormous quantities of hot steam rushing into the air close beside the extensive glaciers and snow-fields of the mountains, the weather is necessarily about as bad as could be.

From the head of the valley, where conditions made it necessary for us to camp, we could often look out of our door through a storm that threatened to tear the tent from the ground and see bright sunshine and good weather five miles down the valley.

There was rain almost every day we were in the valley—not the gentle mist familiar to dwellers of southeastern Alaska, but real rain in big drops, driven



Photograph by Robert F. Griggs

ONE OF THE BIGGEST VENTS IN THE VALLEY

Some idea of the size of this great earth seam, from which perpetually roll clouds of steam, may be gained when it is realized that the two black dots, indicated by the two arrows, are men standing at the edge of the opening

before the gusty winds that penetrated everything, until our tent roof looked like a basket. How we wished to study the valley from the shelter of a house with a real roof, where we could keep things dry and contemplate the wonders of nature with some degree of personal comfort!

But in the intervals between the rains the sunshine made up for all the hardships we endured. The weather here is somewhat like the little girl with the curl: "When it is bad it is undeniably horrid, but when it is good it is so very, very good" that one straightway forgives the evil moods. Whenever the skies cleared we instantly forgot the discomforts which we had endured, and one and all gave ourselves up to admiration of the surpassing beauty which surrounded us.

Having thus established ourselves in the valley, we proceeded to prepare for the study of the many scientific problems presented by this unique place.

One of the first peculiar discoveries made by us when we arrived in the valley was the great number of dead insects around the vents, where they had been killed by flying into the live steam. Hine, therefore, came up for a few days to study the insects with the purpose of ascertaining how they get into the valley and where they breed (see page 135).

The larger animals are practically absent, but we found occasional tracks of bears, wolves, and wolverines, which had crossed the valley from one range to the other.

Most of these were old, but one day I found the tracks of a bear which had crossed during the night. I wish I could have watched him when his feet sank into the patches of soft, scalding mud that lay in his way. He must have been treated to the surprise of his life! But however he felt, he kept right on straight across the valley, without making the slightest deviation to avoid the bad places, often sinking deep into the hot mud (see page 152).

Maynard, with one of the others for assistant, toiled up to the summits day after day with 30-pound packs to secure the topographic map which is the necessary basis for all our statements of areas and sizes. His was arduous work and the effort was often wasted, for the days when the mountain summits are perfectly clear, as is necessary for this work, are rare around mountain passes anywhere, and here especially so.

Sometimes the weather seemed to have an almost fiendish power of opposing their plans, for several times from the valley we could watch and see a thin cloud hanging all day to the very summit, on which they stood shivering, while the other mountains all around were clear. More than once it seemed as if there would not be enough clear days to complete the observations, but in the end they succeeded in getting the data for an excellent map.

PRACTICALLY ALL PLANT LIFE DESTROYED

The most disagreeable, as well as one of the most difficult, tasks fell to Shipley, who collected samples of gas from the vents for analysis, from which it is hoped to learn much about volcanoes in general and those of this district in particular. In laying out work in advance, to poke a glass tube into a vent and pump the gas into a collector sounds easy, but in the field all sorts of difficulties crop up which require great patience and resourcefulness to surmount. Apparatus will not do what is expected of it; tubes clog prematurely or snap in the heat.

Moreover, a volcano is not an easy customer to deal with at close range. When, after some trouble, one is in a position where he can get his sample, and a sudden shift of wind brings a cloud of hot, blinding gas around him, he is placed in a difficult, not to say dangerous, situation. More than once our gas collectors became lost, but fortunately the precious samples were all secured without mishap and a considerable amount of other valuable chemical work done.

Only the botanists were without employment, for in the formation of the valley all life was completely annihilated and plants are practically absent. Not quite so, however, for around some of the vents moss and algæ are beginning to start where bathed by the warm breath of the fumarole, from which they derive, beside the constant moisture, their supply of nitrogen in the form of ammonia,

Photograph by J. W. Shipley

MOUNT CERBERUS, LYING STRAIGHT ACROSS THE HEAD OF THE VALLEY, RESEMBLES A CROUCHING ANIMAL GUARDING THE ENTRANCE TO HADES

This mountain is practically surrounded by fumaroles emitting jets of steam (see also page 140)

which is given off in considerable quantity by the vents.

The beans we dropped on the "kitchen floor" near our fumarole also sprouted and grew rapidly on the warm ground, soon making a bright spot of green; but they were short lived, for the roots were killed wherever they touched the acid soil.

The absence of vegetation gave me opportunity to spend all of my leisure in studying the manifold geological problems of the place, which presents a remarkable and unique exhibition of geological forces.

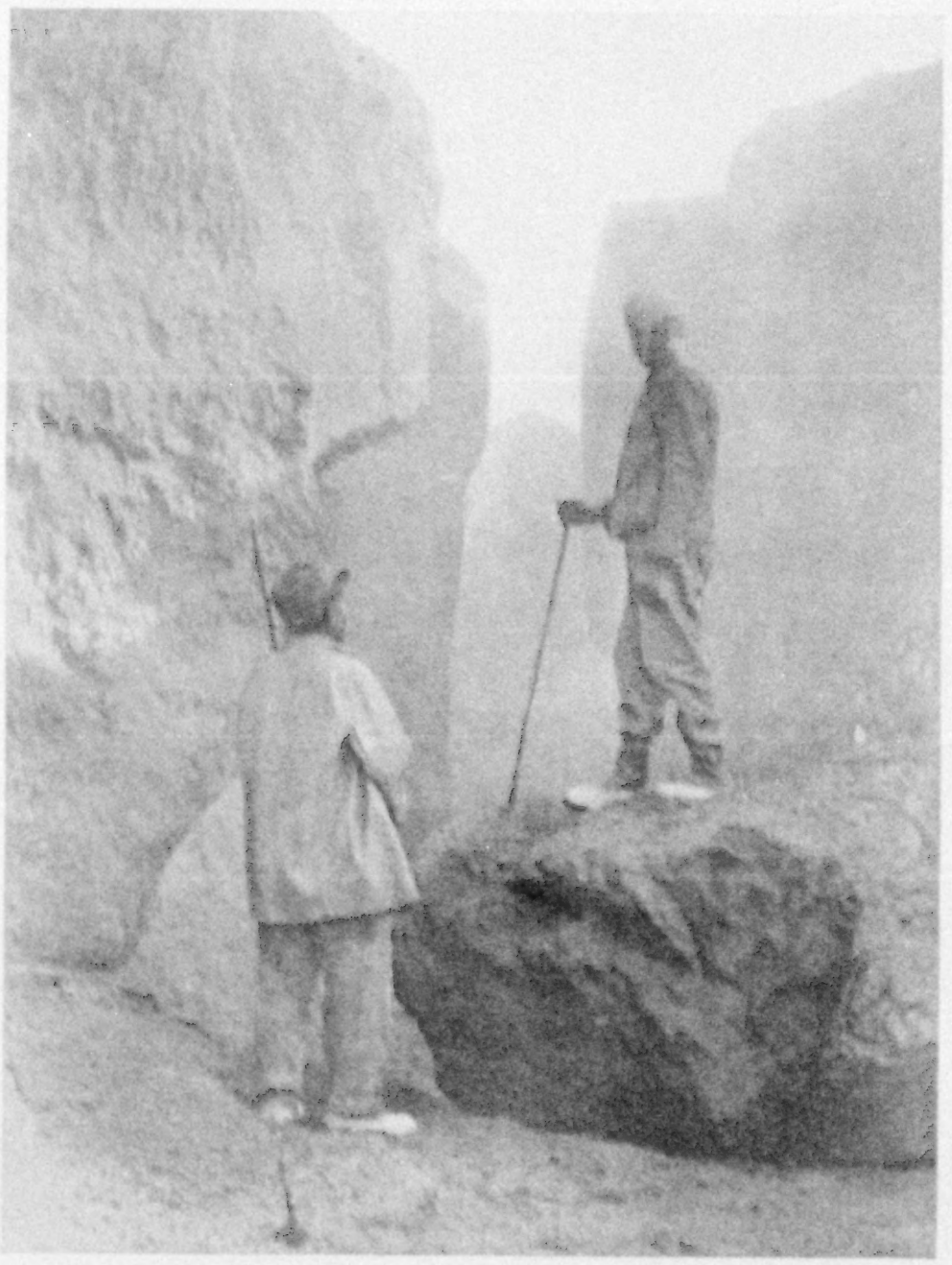
A COMPLICATED SYSTEM OF SMOKING VALLEYS

The area in which the vents occur is not a simple valley, but includes a complicated system of branches, the whole forming a tract of very irregular shape. The main line of activity extends directly transverse to the axis of the Alaska Peninsula from Katmai Pass northwestward toward the head of Naknek Lake. In this direction vents occur all the way down the valley as far as the bend to the north. There is clear evidence that when the steam jets burst forth this line of activity also extended straight across the pass and down through the upper valley of Mageik Creek to Observation Mountain.

As one ascends this main valley from the Bering Sea side, he sees lying straight across its head a mountain resembling a crouching animal guarding the entrance. This mountain, which we thought appropriate to call Cerberus, is practically surrounded by fumaroles, for a small branch valley runs around from the pass. In front of Mt. Cerberus the valley is very wide, sending a short branch westward under the glaciers of Mageik and another longer one to the east toward the crater of Katmai (see page 140).

In the latter branch the climax of the activity of the whole district is to be found in the two remarkable features described below—Falling Mountain and Novarupta Volcano. We were astonished to find that this branch has no head, but continues round by Mt. Katmai and back to the main valley under the slopes of Knife Peak.

The mountains, thus surrounded by a complete ring of vents, are so cut up by faults that we named them the Broken Mountains. They are bisected by a smaller branch valley, also full of vents, stretching across from Novarupta. Activity occurs in yet another branch on the opposite side of the main valley well down toward the bend. The total length of all of these smoking valleys is 32 miles. The area is 70 square miles, the average width being 2 miles.



Photograph by J. W. Shipley

EXPLORING A STEAMING FISSURE

With the steam so thick that one cannot see his way, one often wonders where he is coming out

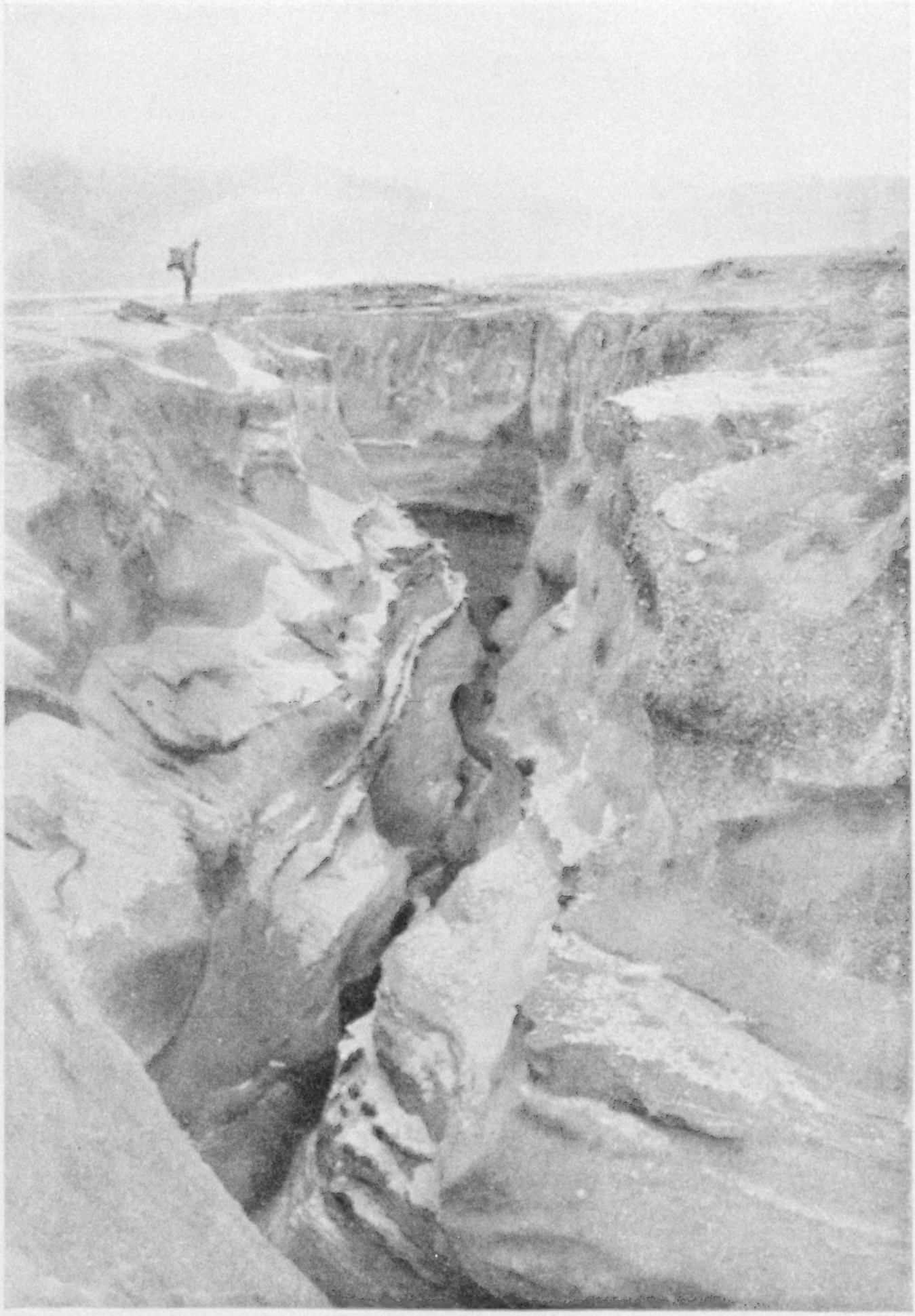
COMPARISON WITH THE YELLOWSTONE PARK

With these dimensions at hand, it will be interesting to compare the valley with the Yellowstone Park. In the Yellowstone there are about 4,000 hot springs and a hundred geysers scattered over an area of some 3,000 square miles. The geysers, which are the most interesting feature, occur in several isolated geyser basins, whose total area is hardly 20 square miles. The largest of the geysers, which play but seldom, shoot up a column scarcely exceeding 300 feet in height. The column of Old Faithful, which is the only geyser the tourist can count on seeing in action, is about 100 feet high.

In the Alaskan Valley there are in constant action thousands of vents whose columns exceed that figure. The columns of several of the largest vents may, when conditions are right, ascend more than 5,000 feet into the air or, under the influence of the winds which sweep the valley, trail along the ground for two or three miles.

WHY THERE ARE NO GEYSERS

One of the questions most frequently asked by persons interested in the region is whether or not there are geysers.



Photograph by Robert F. Griggs

A TYPICAL MUD CANYON IN THE VALLEY OF TEN THOUSAND SMOKES

These curious, twisting gorges, though only a few feet wide, were often 60 feet deep

Photograph by J. W. Shipley

INSPECTING THE CAVERNOUS MAW OF A GAS-EMITTING VENT

The gases from these openings are transparent until they begin to condense in the atmosphere. Therefore it is frequently possible to look into the depths of the earth for many feet.

None was observed, and the conditions are such as to make their development unlikely for the present. Geysers belong to a declining stage of volcanic activity, while the present region is in a youthful stage. A geyser consists essentially of a column of hot water mixed with steam, which is periodically projected into the air by the sudden formation of the steam from water gradually heating up to the boiling point.

A geyser can exist, therefore, only in rock cool enough to permit the accumulation of the water. The vents of this steaming valley are so hot that they would instantly vaporize any ordinary quantity of water that might find its way into them. One can readily see that if the valley cools off gradually there may come a time favorable for the formation of geysers.

To attempt any catalogue of the individual vents or any description of them would be utterly futile. They vary all the way from microscopic jets of gas to mighty columns of smoke which overtop the mountains. To explore the valley thoroughly and become acquainted with the characters of the various vents would require a residence of several months. We were continually surprised to find new and interesting features in places with which we thought we were perfectly familiar. The smokes in general, however, may be classed as coming either from craters or fissures.

THE CRATERS OF THE PLAIN

The craters are much less numerous than the fissures, but include some of the largest and most active of the vents. All of them are located in the floor of the valley, not around the edges. They average about 100 feet in diameter. The rims are slightly raised above the general level, showing that they were produced by explosive action (see page 135), but the amount of material in these crater rings is, in general, very much less than enough to fill the cavity. Within they are perfectly conical pits, sloping down into the throat at the bottom.

The steep sides, standing at the critical angle, remind one of the pits which ant lions dig in the sand. Indeed, little imagination is required to picture the old devil at the bottom waiting to devour whatever slips over the edge; for the sides are so nearly perpendicular that if any one made the first slip he could never get out again.

The smoke from these craters comes out in such volume that often the hole is completely filled and its outlines concealed, but by waiting a few moments at the windward side one can usually see the inside of the crater, and sometimes for an instant catch a glimpse of the throat at the bottom—usually a perpendicular tube about 10 feet in diameter leading down into the bowels of the earth. On favorable occasions one may see as much as 50 feet below the surface of the plain; but these momentary glimpses did not give us much information as to the character of the rock at that depth. We could not even be sure whether it differed from the surface mud.

Many of the craters stand apart from other vents. In other cases they are grouped together in areas with few fissures. In a few places the evident relations between craters and fissures furnish perfect models of the relations generally believed to underlie the great lines of volcanic activity that girdle the world. In such a place a long fissure has here and there thrown up craters around points of special activity, forming lines of craters standing up out of the fissure and locally obliterating it without concealing their relations to it.

In the same way such a series of volcanoes as the Aleutian chain, of which the present district is a part, are supposed to be built up around the openings from a continuous fissure in the earth's crust, extending for several hundred miles throughout the length of the chain.

THE FISSURES

Much the greater part of the steam in the valley comes to the surface, not in these craters, but through the innumerable fissures. There are readily seen to be two sets of these—bands of marginal fissures, several together, running around the edge of the valley in parallel lines, and single central fissures, which crisscross the floor in all directions (see pages 125 and 126).

Photograph by L. G. Folsom

THE MOUTH OF A VENT IN THE SIDE OF A GULLY

The entomologist with his bug net seems incongruous in such a place, but around some of the vents there are thousands of dead insects, killed by flying into the hot steam

Photograph by D. B. Church

SMOKING FISSURES AT THE FOOT OF FALLING MOUNTAIN

"To convey an adequate impression of Falling Mountain, the record of a phonograph rather than of the camera would be necessary; for in a period of maximum activity there is a continuous series of bangs, thuds, and rattles, as masses of rock of all sizes are loosened from their hold and roll down the two-thousand-foot slopes of the mountain."

The marginal fissures usually stand open, like great cracks in the surface, into which one might fall unless careful. Sometimes the fissures were formed merely by the cracking open of the ground, but often they are lines of faulting, one side standing higher than the other. They are often steaming hot for long distances without a break, and at intervals contain vents from which issue some of the biggest smokes in the valley.

While the smoke from the craters comes out quietly, in vast, rolling clouds, that from the fissures often is emitted under considerable pressure, roaring and hissing. If one tosses pebbles into the mouths of these vents they are so buoyed up by the rising gases that they are either immediately spewed out again or they sink slowly down through the rising steam like feathers settling to earth. Such vents are the hottest places in the valley; the gases from them do not condense for several yards beyond the orifice (see page 127). They furnished some of the most satisfactory places for the collection of gases for analysis, because of the ease with which the collector could assure himself that his sample was free from contamination with the atmosphere.

The fissures of the central valley floor, unlike those along the margin, do not stand open, but are often recognizable only by the lines of incrustations deposited along them. Although they also contain some of the largest vents, the gas from many of them is not visible on a bright, hot day, and only during wet weather does one realize, by the long lines of little smokes he sees stretching across the valley in every direction, how much gas such fissures are continually pouring out into the air.

Naturally we were anxious to find out how deep some of these fissure were, but we could not gratify our curiosity. To sound some of the less active vents with a stone tied to a rope was easy, but this line was only 100 feet long and was too short to reach the bottom of those we tried.

The greater part of the gas given off is undoubtedly steam, but even the smaller vents contain many substances, in addition, which must have originated deep down in the earth. In many of the larger and hotter vents the proportion of other gases increases so greatly that the emanation is changed in character and does not look like steam, but takes on a bluish cast like the smoke from the combustion of a fire. In a few cases this blueness is so pronounced as to be noticeable at a distance of several miles.

The principal cause of this blue smoke appears to be sulphur dioxide, the same gas that is given off by burning sulphur. Other factors probably coöperate in producing this appearance, but in what degree they are responsible cannot be determined until the chemical analyses are completed.

A BEWILDERING COMPLEX OF ODORS

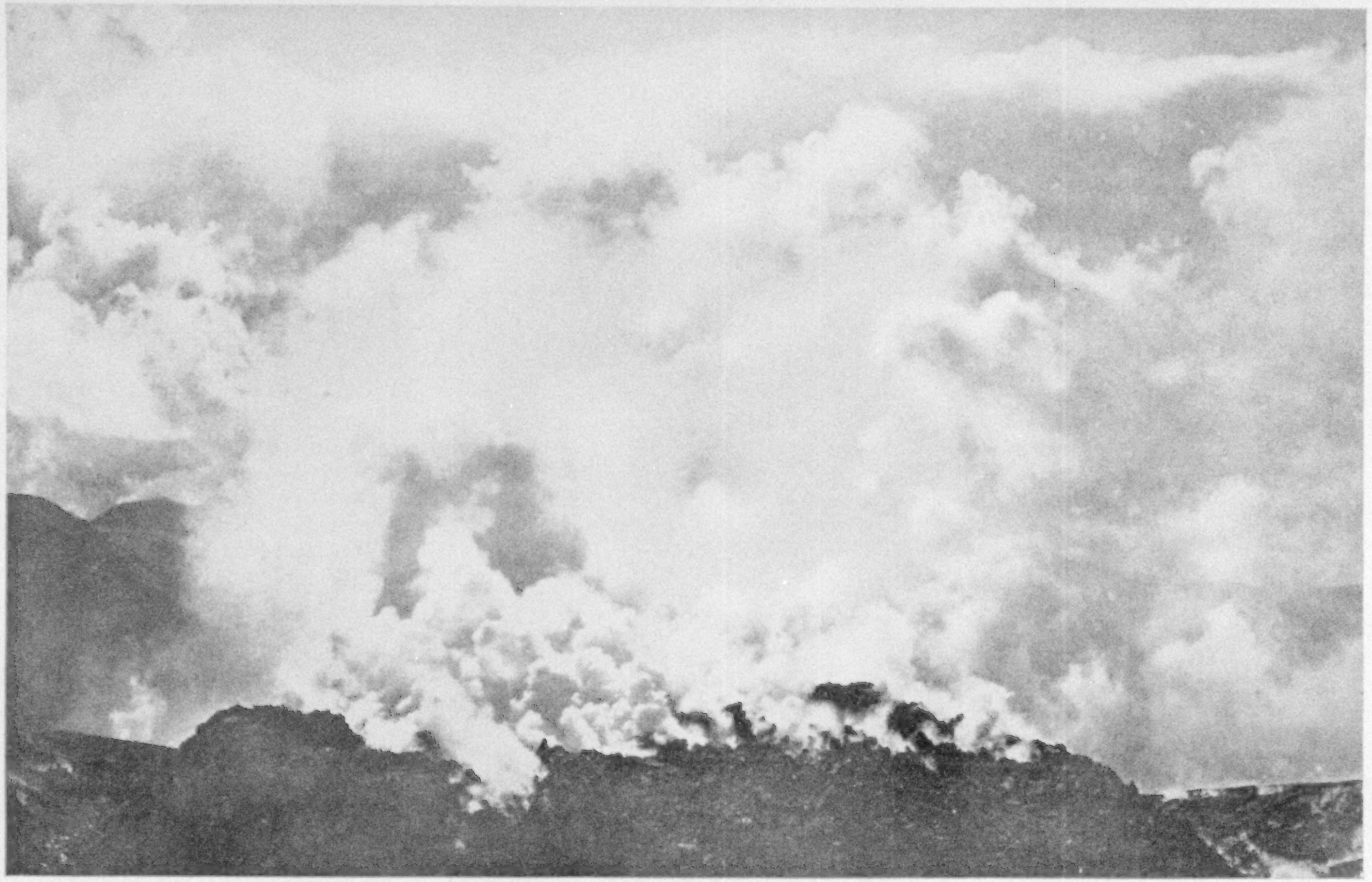
The many substances rising through these vents result in an extremely curious combination of odors, which Dr. Shipley, with the trained nose of a chemist, thus describes:

"As we entered the valley along a deep, dry, watercourse, we observed, from time to time, a peculiar, indefinable, and not unpleasant odor. Passing close to the active vents, the odor of hydrochloric acid and hydrogen sulphide could be detected easily. From certain of the active areas a disagreeable smell, unlike any odor that we had ever encountered, arose. It was somewhat suggestive of a pig-sty, a horse-stable, and sewer gas, yet we could not relate it definitely to any previously observed smell.

"Whatever the gases are, that rise from the vents in the floor of this wonderful valley, collectively they offer a considerable task to the olfactory organs in differentiating the known from the unknown. At a distance of 20 miles from the valley, one was certain one moment that the gas was sulphur dioxide which the wind bore to him, the next moment it was hydrogen sulphide, and the next, both or neither. This same elusive uncertainty clung throughout the whole period of our stay in the valley. It was only in the vicinity of a vent that the individual gases could be identified with certainty by the sense of smell."

All of the vents, even the smallest, whose fumes are too slight to be visible,

XUM



Photograph by Robert F. Griggs

THE LAVA PLUG OF NOVARUPTA FROM THE CRATER RIM

"Novarupta apparently began with an explosive violence surpassed in this district only by Katmai itself. . . . After explosive activity had ceased there was a slow extrusion of pasty lava from the vent. This has been pushed up until it forms a great plug of lava. Its surface is covered with an indescribable confusion of fragments of all sizes, shapes, and colors. We could only guess how far it might be through this mantle of fragments to the still molten lava beneath."

incrust the mud in their vicinity with copious deposits, giving the adjacent ground a most fantastic appearance. These incrustations take on all colors imaginable and in many places give rise to very beautiful formations. The prevailing hues are perhaps those due to the gray and green and yellow alums, which build out curious crystalline structures simulating lichens growing on the ground.

DEPOSITS ALL COLORS OF THE RAINBOW

Over large areas the ground has been burned to a bright red by the heat. The variations in the intensity of the color produced are extremely beautiful, including, as they do, all shades from orange and brick red to bright cherry reds, purples, and on down to black, with occasional contrasting streaks of blue. This type of coloration is most pronounced in areas originally occupied by small fumaroles which have burned out. In places the ground has the appearance of having been burned with fire for a mile at a stretch.

Around the larger vents the ground is more commonly colored a dull pink by a deposit which cements the loose, sandy particles of ash into compact masses like concrete. In some of the largest vents such pink and red incrustations are the only ones developed, but more often spots of brilliant yellow and orange also occur in beautiful contrast with the pink ground color.

FLOWERS OF PURE SULPHUR

These yellows are mostly due, of course, to sulphur, which is very common. There are some places where one can gather crystals of sulphur, almost free from impurities, by the bushel. And up on the mountain side above the crater of Novarupta is a great yellow spot of sulphur conspicuous for miles. Sulphur occurs most often in small crystals compacted into solid cakes, but occasionally we found it lining the throat of a fumarole in long, branching, needle-like crystals (flowers of sulphur), very beautiful under a lens.

With the yellow sulphur are often deposited masses of a bright orange crystalline substance whose composition we did not know. These are generally deposited in the cracks of the characteristic blue mud that abounds around many of the groups of fumaroles, especially in places where there is considerable diffused activity, reaching the surface through innumerable small jets rather than by a single large vent.

Needless to say, the color combination presented by the orange and blue is as beautiful as it is unusual. In similar fumarole groups where the activity is not quite so intense the surface of the same blue mud is covered with a rich chestnut-brown crust, whose varied tones would of themselves excite the highest admiration were they not eclipsed by the other more brilliant colors.

In still other places the prevailing deposits are of a white, chalky character, recalling the geyserite of the Yellowstone Park. These white vents excel all the others in the delicacy of their coloring, for they are lightly tinged with yellow and pink, giving them a creamy, flesh-colored appearance, even more beautiful than the brilliant masses of color elsewhere developed.

In addition to all these colors, algæ have formed a deep-green incrustation over the ground close up to some of the vents, in places where at first sight one would suppose the ground was too hot to permit the activities of organisms of any kind; but the insulating properties of the soil are so good that great variations in temperature may occur within a few inches.

We much desired to make accurate color studies of the characteristic deposits, but the time at our disposal was altogether too short to permit of such detailed exploration. Indeed, it should be emphasized that there is material in this wonderful valley to repay months of careful study, and that all we could do was to examine hastily the major features, leaving thousands of important seats of activity without even so much as a cursory visit.

But there are a few special features which cannot be passed by without more detailed description.

FISSURE LAKE

Across the head of the valley stands the three-peaked bulk of Mt. Mageik, smok-

XUM

Photograph by C. F. Maynard

PANORAMA OF THE VALLEY OF TEN THOUSAND SMOKES, LOOKING FROM BROKEN MOUNTAIN

From left to right: Mt. Katmai, Novarupta (see page 145), whose smoke conceals Trident and Falling Mountain (see page 141); Katmai Pass, Mt. Cerberus (low), Mt. Mageik, and Mt. Martin, whose smoke is barely visible

ing away continuously into the clouds far above. Down its sides tumble three magnificent glaciers broken to fragments by the steep descent. The tongues of all three come down to the level of the valley, where they stop abruptly without moraines, as though melted back by the heat.

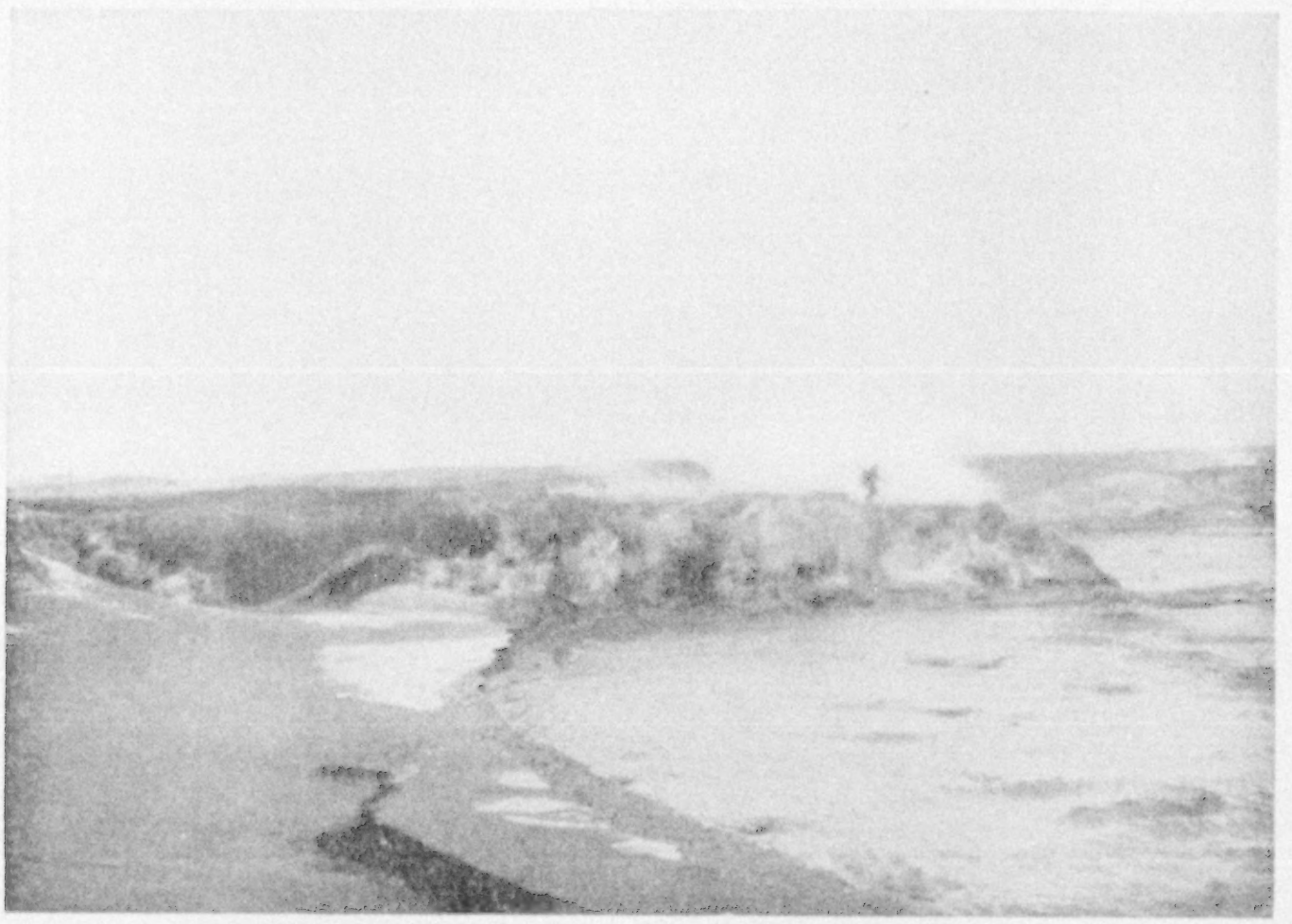
Near the foot of these glaciers occurs the most conspicuous fissure to be found anywhere in the valley. It is 200 to 400 feet wide, with perpendicular walls, one of which stands about 35 feet higher than the other. The depth could not be ascertained because it is filled by a beautiful lake of clear, green water. Standing just at the foot of the glaciers, this fissure is one of the most picturesque spots in the whole valley (see page 146). Along the sides are numerous snow-drifts, from which miniature bergs break off and float away in the clear water.

WARM WATER FROM SNOW-DRIFTS

Fed by the glaciers and melting snows, Fissure Lake would be expected to be icy cold, but on the contrary it is decidedly tepid in spots, where heat evidently is received from below. One of the most amusing incidents of the whole trip occurred when our chemist, poking his thermometer into everything, discovered this fact.

I was coming along a little behind, and he, pretending to need my assistance, asked me to tell him the temperature of the water coming out from under the edge of a snow-field. Willing to answer even a foolish question, I had the words "ice cold" on the tip of my tongue when my fingers touched the water. The speaking expression froze on my face and I carefully dipped my hand in again. It was actually warm! How he did laugh at my discomfiture!

The snow-fields which surround the valley send trickling rills down the slopes, but these dry up and disappear long before the floor of the basin is reached. From the glaciers, however, comes a considerable stream, which runs, in spite of all obstacles, clear through the valley, dwindling to almost nothing before passing out of the hot area. These waters thus so nearly forget to run that we christened the stream the River Lethe.



Photograph by Robert F. Griggs

FUMAROLES ALONG THE RIVER LETHE

Here is a place where one could easily cook his fish without taking it off the hook—if there were any fish to catch. In places the steam actually bubbles up through the cold water.

The appropriateness of this name is increased not only by its course, which lies through the center of Hades, but also because the uncanny waters, full of deep-brown silt from the glaciers, have a most weird aspect as they rush swirling down the valley.

WHERE YOU COULD COOK YOUR FISH WITHOUT TAKING IT OFF THE HOOK

In many places the river cuts straight across lines of volcanic activity, and here we see how close the antagonistic elements—"fire" and water—may approach one another without disturbance. The mud, which lines the banks, is so perfect a non-conductor that within a few inches of the cold water the ground is boiling hot. There are places where the steam from small fumaroles actually boils up through the water of the river! Several good-sized vents are located on the very banks of the river.

Here one could catch a fish in the stream and cook it without taking it off the hook—if only there were any fish, for one can hardly imagine fish frequenting this murky stream. There is, however, no real reason why they might not occur; for, in spite of the fact that the very banks are boiling hot, the waters maintain their glacial temperature of about 48° F. throughout the valley.

The climax of activity in this wonderful valley occurs in the northeast angle, toward Mt. Katmai, where there are two features of surpassing interest—Falling Mountain (see page 136) and Novarupta Volcano (see page 138).

FALLING MOUNTAIN

At first sight, Falling Mountain looks no different from other lava mountains near by, except that one face is a perfectly fresh rock cliff without any covering of ash. On account of the quantity of surrounding steam, one is not apt to notice that this rock face of the mountain

Photograph by Clarence F. Maynard

PANORAMA OF THE VALLEY OF TEN THOUSAND SMOKES, FROM BROKEN MOUNTAIN, SHOWING ESPECIALLY WELL THE "HIGH MUD MARK" AND THE GRADIENT OF THE MUD FLOW

is steaming like the ash fissures in the valley. As one comes up the valley, therefore, he will give scant notice to this mountain until his attention is forcibly drawn to it by the big fall of rocks which is sure to occur within a few minutes. Then he will turn away for a minute or two, only to have his attention brought back again by another rock fall.

After one has spent some time near the mountain and on repeated visits always hears the same thunder of the continuous rock falls, the realization gradually dawns on him that here is a feature as remarkable as any other in the valley; for when one's interest is aroused to inquire as to the cause of the phenomenon he begins to see that such a continuous series of rock falls could not be produced by any ordinary agency.

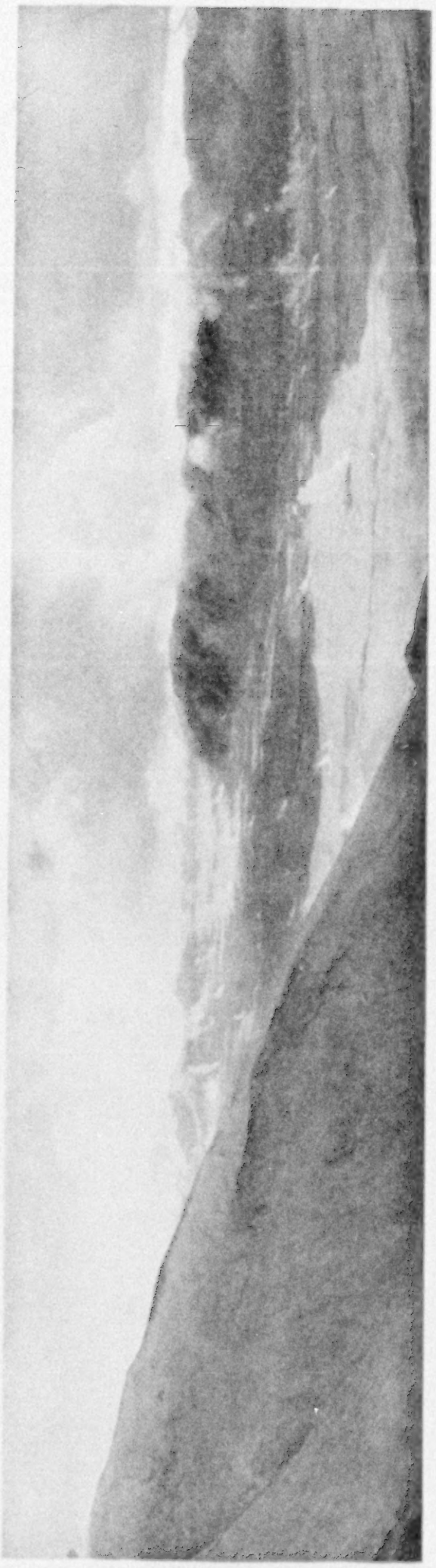
To convey an adequate impression of Falling Mountain, the record of the phonograph rather than of the camera would be necessary; for in a period of maximum activity there is a continuous series of bangs, thuds, and rattles, as masses of rock of all sizes are loosened from their hold and roll down the two-thousand-foot slopes of the mountain. Always the sound rather than the sight draws the attention, for one often has to look very hard before he can find the rocks that make the noise, so high up on the broad cliff do they start.

HUGE ROCKS SHOT FROM THE MOUNTAIN

The rocks which one is apt to see thus in a casual visit vary in size from small stones to boulders weighing several hundred pounds, but the aggregate fall in an hour reaches several tons.

At the base of the mountain are much larger masses of rock which have come down from above like the smaller ones. The largest of these is a steep-sided conical pile, measuring 500 feet in circumference, which stands out in the floor of the valley a hundred yards beyond the end of the talus slopes. There are several others nearly as large and similarly detached from the talus slopes, where most of the material lodges.

As one looks at these huge piles, made up of fragments of loose rock, dropped as though spilled from same aërial cableway in this great mine of the gods, he



Photograph by Clarence F. Maynard

HALF WAY DOWN THE VALLEY OF TEN THOUSAND SMOKES, LOOKING TOWARD KATMAI PASS FROM AN ELEVATION ON THE EASTERN SIDE

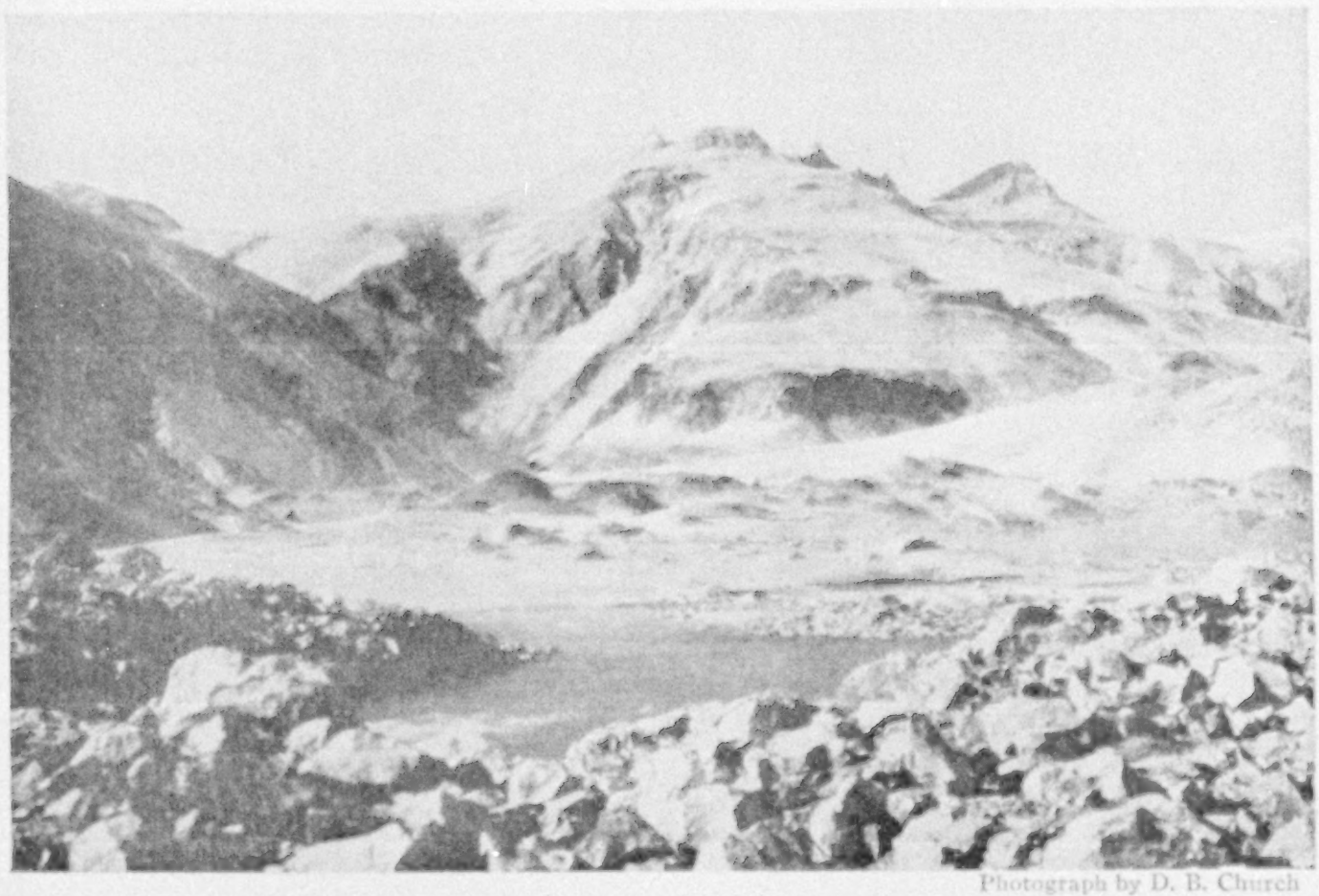
cannot fail to wonder how they could have reached their present position. Lying, as they do, on top of the ash, they evidently have been deposited there since the eruption. As one looks around for a source, he is strongly inclined to suspect that these immense chunks were shot out from the mountain directly to their present position, without a preliminary roll down hill, which surely would have dissipated the fragments and have left a tremendous furrow behind, where they rolled across the soft mud in which they lie.

As one approaches closer to the foot of the mountain he sees other evidence which adds weight to this hypothesis. Along the base of the mountain is a deep, wide fissure, that would stop any of the rolling stones, which, indeed, seldom reach it. But beyond this fissure are many rock fragments of all sizes. Among these are also found the marks where they struck, deep cuts into the ground. Some of these are quite fresh, so that as one walks among them he watches the precipice above apprehensively, with a view of dodging any missile which may come his way.

STEAM ISSUES FROM SOLID ROCK

Some of these pieces are still solid rock, but others have completely disintegrated into small fragments since their discharge from the mountain. The appearance of these fragmented rocks is very similar to that of rocks which have spawled under great heat or broken up after the repeated effects of freezing and thawing, but the disintegration is very much more complete here than one sees in such cases. These rocks look, therefore, as if they had been broken up by forces within themselves.

When one has made this observation he looks with renewed interest on the steam escaping from the solid rock above and turns to the large piles from some of which steam is still escaping in considerable volume (see page 136). An examination seems to indicate that the steam comes from within the piles themselves, rather than from the ground beneath; but most of these are so covered with loose fragments that it is difficult to observe the origin of the steam. We



Photograph by D. B. Church

A PORTION OF THE ROCK SLIDE FROM THE SLOPES OF NOISY MOUNTAIN

Unlike Falling Mountain, one of the phenomena of the Valley of Ten Thousand Smokes, Noisy Mountain, in the upper Katmai Valley, gives off no steam, yet there is a constant rumble of falling rocks from its sides. Note the conical piles of rock in the middle distance (see page 143).

found places, however, on these piles clean of all debris, where steam could be seen issuing directly from the solid rock, just as one sees it high up on the mountain side.

If such evidence were sufficient to permit one to draw positive inferences he might conclude that Falling Mountain is really a mild sort of explosive volcano in which the explosions occur in solid rock rather than in liquid lava. But the presence of a similar active mountain in upper Katmai Valley (Noisy Mountain), from which no steam issues, would make one hesitate in drawing such a conclusion. A more critical study of these curious mountains than was possible, with our limited facilities, ought to yield valuable results.

NOVARUPTA VOLCANO *

Directly opposite the precipices of Falling Mountain lies Novarupta, the greatest of all the vents in the valley. This, though newly formed at the time of the big eruption, is one of the world's largest volcanoes. It is, indeed, a new volcano, differing materially from most of the "new" vents that appear, in that it is not located on the top of an old volcanic mountain, which had erupted before and was in reality only dormant (see p. 138).

On the contrary, it burst through in a new place along the margin of the old volcanic complex, appearing not in igneous rock, but in sedimentary sandstone adjacent to former igneous extrusions. This vent is located not on a mountain top but in the bottom of a valley, which before the eruption gave no indication of the volcanic forces beneath.

Novarupta apparently began with an explosive violence surpassed in this district only by Katmai itself, for quantities of its pumice are scattered over an area ten miles in diameter, forming deposits in places more than fifty feet deep (see page 145). In these deposits cinders

* The name suggested by Mr. Folsom is here published for the first time.

weighing upward of a hundred pounds are frequent, and everywhere the ejecta are much coarser than the ash from Katmai, indicating that the explosions were less violent.

After the first violent outburst the activity apparently gradually diminished in intensity until most of the ejected material was thrown only a short distance, forming in its fall a circular crater ring immediately surrounding the vent. This being seven-tenths of a mile in diameter, is one of the largest explosion craters in the world, very much larger than Pelée or Vesuvius, and would be a feature of primary interest in the region were it not dwarfed by the vast crater of Katmai.

THE GREAT LAVA PLUG OF NOVARUPTA

As the explosive period drew to a close the lava became more and more pasty, until among the last stones thrown out were numerous masses of lava stiff enough to retain their shape, yet so hot that their surface is cracked open from the contraction incident to cooling, giving the characteristic "bread crust" appearance. These are the only lava "bombs" found in the Katmai district. Nowhere are there any typical bombs formed by masses of lava thrown out while still liquid and assuming a rigid spheroidal form while still in the air. Indeed, nowhere else were even "bread crust" bombs found.

After explosive activity had ceased there was a slow extrusion of pasty lava from the vent. This has been pushed up until an immense plug of lava has been formed 1,200 feet in diameter and 250 feet above the floor of the crater. The surface is covered with an indescribable confusion of fragments of all sizes, shapes, and colors, formed by the fragmentation of the lava from the strains set up by unequal contraction while cooling.

We could only guess the distance through this mantle of fragments to the still molten lava beneath. The fact should be noted that nowhere in the whole district did we see any evidence of a lava *flow* in connection with the present eruption. This mass of rock, which from the beginning was evidently very pasty, is the nearest approach to molten lava to be found in this region.

Photograph by Robert F. Griggs

A CHUNK OF PUMICE THROWN OUT BY NOVARUPTA

So violent was the explosion of Novarupta that quantities of its pumice are scattered over an area ten miles in diameter. In these deposits, cinders weighing upward of a hundred pounds are frequent (see page 144).

That somewhere beneath the surface of this plug the lava is still molten is abundantly evidenced by the tremendous quantities of smoke continuously given off. Often this cloud fills the sky for miles, even drifting through Katmai Pass and obscuring considerable areas on the other side of the range. At other times the smoke forms an erect column as much as two miles high (see page 140).

Around Novarupta the earth is all shot to pieces with more and larger steaming fissures than are to be found elsewhere, so that only with difficulty one finds a path through the bewildering maze of vents. The climb over the rim of Nova-

Photograph by J. W. Shipley

A FUMAROLE ON THE BANK OF FISSURE LAKE

"Near the foot of three glaciers occurs the most conspicuous fissure to be found anywhere in the valley. It is 200 to 400 feet wide, with perpendicular walls, one of which stands about 35 feet higher than the other. Its depth could not be ascertained because it is filled by a beautiful lake of clear, green water. Along its sides are numerous snow-drifts from which miniature bergs break off and float away in the clear water. Fed by glaciers, one would expect Fissure Lake to be icy cold, but, on the contrary, it is decidedly tepid in spots, where it receives heat from below."

rupta and down beside the plug of lava is the most fearsome adventure afforded to the explorer of the valley, for here there is so much steam that he is more than likely to be surrounded in a hot cloud, blown by the fickle wind. Two of the party so surrounded in this vicinity once became completely confused, disagreeing as to the way home, and finally taking the wrong course until they were set right by crossing the trail made by a previous party.

VALLEY OF TEN THOUSAND SMOKES WITHOUT A RIVAL

In order that the reader may justly estimate the status of this valley among the wonders of the world, we ought to make some comparisons with other similar regions, but in truth there is no other region with which the Valley of Ten Thousand Smokes can be compared. Niagara finds a rival in Victoria Falls. The Rotorua district of New Zealand is a competitor of the Yellowstone. The Crater of Katmai must stand comparison with Kilauea and Crater Lake.

Not so with the Valley of Ten Thousand Smokes. It is unique. *Nothing approaching it has ever been seen by the eye of man.* To find a parallel we must search the records of geology, for here we have such a volcanic outburst as the geologist finds recorded in the rocks of the past, but never before has had an opportunity to observe in the world of the present.

In the size of the vents and the quantity of smoke given off the valley is so far beyond other volcanic districts that no other place can for a moment be compared with it. Quite well within the truth, we might say that the sum total of the emanations from all the other volcanoes of the American continent, from the Aleutians to Patagonia, except during rare periods of a dangerous eruption, is much less than is given off within the radius of one's vision from the Valley of Ten Thousand Smokes.

Indeed, if one could pick up all the other volcanoes in the whole world and set them down together, side by side as close as they could stand, they would present much less of a spectacle, always excepting a period of dangerous eruption, than does the Valley of Ten Thousand Smokes every day in the year.

THE LAST DAY IN THE VALLEY

I can never forget my last day in the valley. We had been lying in our sopping tents for two days, unable to stir outside in the blinding storms. The rest of the work was pressing, for I had already overstayed the time allotted for the valley. In the morning I had announced that we would move out that night, regardless of the weather, and had given orders for the equipment to go down. We started out for some last pictures in rain and mist which made it impossible to find our way around through the steam, but after a couple of hours there came a break.

The atmosphere cleared and disclosed the sun shining out of a blue sky, spotted with big cumulus clouds, with a light that was dazzlingly bright. I never saw the valley half so wonderful. We exposed our films as fast as we could wind them up, getting within a few hours many of our best pictures. There were a dozen showers during the day, soaking rains, too, but we utilized such intervals to travel from one group of vents to another. We came in at 6 o'clock tired out, but bent on taking out the big photographic outfit for the one grandest panorama of all. But it was too late; because of my own orders we found the camp stripped of everything we needed.

There was nothing to do but follow, so we made up our packs and reluctantly trudged out through the pass and down the other side. I almost wept as I turned for one last look at the marvelous valley, showing off now as never before, for as we came up to the divide, which we were perhaps never to cross again, a magical curtain was unrolled, as a background for the scene, in the most gorgeous sunset I ever saw. The wonderful colors held us almost spellbound for hours, until they slowly faded into twilight, as we rounded the shoulder of Observation Mountain into Katmai Valley.

TESTIMONY OF MY ASSOCIATES

At my request various members of my party have written a brief summary of their impressions, as follows:

XUM

Photograph by Robert F. Griggs

A "BUTTE" IN THE VALLEY OF TEN THOUSAND SMOKES, FORMED OF SOLIDIFIED MUD

Paul R. Hagelbarger, Assistant Botanist.—"Bright sunshine bathed the valley when I first saw it. Even though several miles away, I was awe-struck by the surprisingly large size and striking beauty of the spectacle. There were so many more steam jets than I had even hoped to see that I could only gaze in silent admiration.

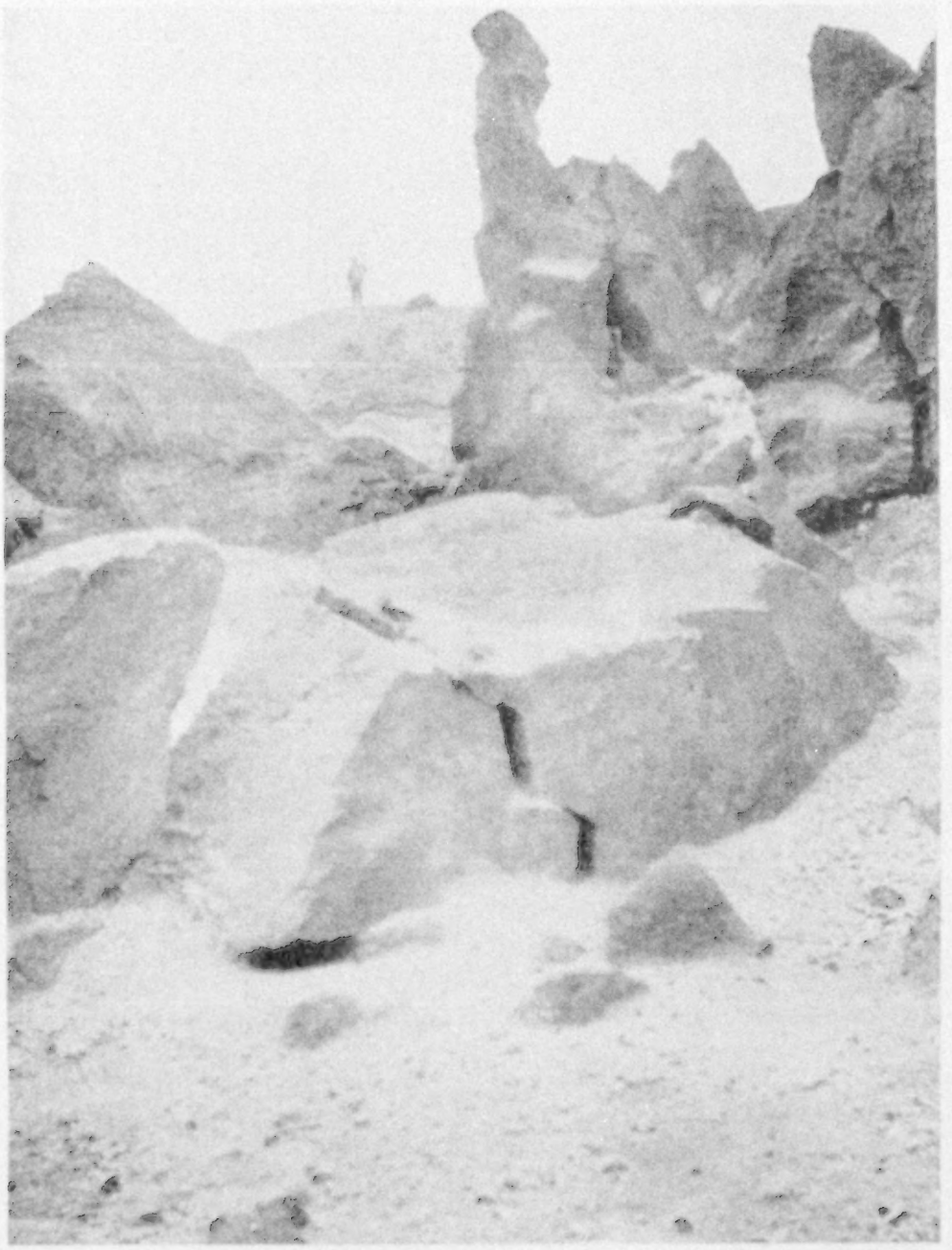
"After living in the valley and working among the fumaroles, my impressions began to change. My amazement at the great area was intensified by the knowledge gained on many trips across the valley floor. The beauty of each individual vent was even more than that of the valley as a whole.

"The thing that stupefied me, however, was the ever-present proof that some terrific energy or force had only recently exerted itself. Everything seemed on such a huge scale. Our tents looked insignificant, pitched among the gaping fissures and the roaring volcanic vents.

"As I came daily to know the area better, I was more and more impressed by

the titanic forces that had been at work here. Human endeavor and achievement seemed dwarfed to insignificance by comparison. I felt out of place and like an intruder in this Land of the Gods. This valley appeared to be on another planet that was in the process of formation.

"I spent 16 days in the valley and was glad to leave, as will be seen in my diary for August 2: 'Came out of the steaming valley for good. Lucky to get out. Glad to see trees and grass again. Feel like I am just awakening after a two weeks' nightmare. Valley is wonderful, but no place to camp. Walter says, "Lots of steam. Hell of a place." Heartily agree.'"



Photograph by J. W. Shipley

HOODOOS IN THE SOLIDIFIED MUD, CAUSED BY FAULTING

SURPASSED HIS WILDEST DREAMS

J. D. Sayre, Assistant Botanist. — "My sensation on first seeing the Valley of Ten Thousand Smokes was one of wonder and astonishment. I was astonished at the great dimensions of the valley and at the countless numbers of fumaroles and fissures out of which the steam issued, to say nothing of the many other gorgeous and magnificent displays of nature. Never in my wildest dreams had I imagined anything to compare with these.

"Greatest of all was my surprise that so much energy could be released in such an easy and quiet manner without apparent injury or danger to any one or anything. I experienced no sensation of fear while staying in the valley, perhaps because my mind was so filled with astonishment and admiration at this great marvel of nature, or because I was foolhardy and did not realize the grave dangers of falling into one of those hot places.

"I had no hatred of the place during my short stay there, although we were surrounded by many discomforts, and I said, soon after we left, that I would like to come back some time and see the place again. I am very proud to say that I was a member of the expedition which overcame the difficulties and hardships and first explored such a wonderful place."

THE COMPLAINT OF A TOPOGRAPHER

Clarence E. Maynard, Topographer.— "To me the Valley of Ten Thousand

Photograph by Robert F. Griggs

OUR WARMING OVEN IN THE VALLEY

We could keep our dinner hot by setting the pot in a hole, scooped out anywhere in the ground.

Smokes is a stretch of country that offers all the usual difficulties of topographic surveying in Alaska, with a few rather unusual ones thrown in for good measure. It is hardly a country to make the heart of a topographer glad.

"The smokes did not impress me with their grandeur or with their wonder as a natural phenomenon. Their ability to make surveying next to impossible did, however, make a very decided impression on me. On the occasional clear days when the sun was shining down the valley they seemed to be always at their best, as Griggs would put it, but to my mind at their worst. On these, the few rare days when it was not raining and the wind was not doing its best to move our camp (rather good judgment on the part of the wind, I should say) they would shoot forth jets of steam which soon took the form of clouds and obscured the country we were trying to work.

"I finally began to believe that the smokes were out to buck me, and became convinced of it when, on one of the rare fine days, I ascended to a peak which immediately became enveloped in fog. This was not unusual, but I was impressed on returning to camp to hear from the more fortunate members of the party that the whole valley had been clear with the exception of the peak I occupied.

"I am not a vegetarian; furthermore, tea cooked in a steam pit is not tea. A tent that never sheds a drop of water is not a tent. A wool comfort placed on the ground which was 110° Fahrenheit in the above tent will steam beautifully. It is a natural phenomenon, but it is not a good bed. I believe I mentioned that I am not a vegetarian. I like bacon in the morning; I like it fried. A steam jet, in spite of its being glorious and a natural phenomenon, will not do this. I am from New England and have decided ideas on baked beans. Again the steam jet fell down. It needs New England training. Steamed beans are beyond the limit of its capabilities.

"I should say the coming of the smokes ruined what might otherwise have been a perfectly good country. My opinion, however, is probably valueless, as being out of tobacco always colors my views."

THE MODERN INFERNO

James S. Hine, Zoölogist.—"A hike of miles over devastation wrought by natural disturbances in the Katmai country naturally puts one into a peculiar state of mind. He is deeply impressed with the enormity of the whole affair and everything seems beyond comprehension. The unusual circumstance of summer with no plant life and no animal life surely is a strange realization.

"Having reached the summit of Katmai Pass, the Valley of Ten Thousand Smokes spreads out before one with no part of the view obstructed. My first thought was: we have reached the modern inferno. I was horrified, and yet curiosity to see all at close range captivated me. Sure that I would sink beneath the earth's crust at almost every

Photograph by J. W. Shipley

COLLECTING GAS FOR ANALYSIS FROM A SMALL VENT AMIDST A MAZE OF FUMAROLES

"In laying out work in advance it sounds easy to poke a glass tube into a vent and pump the gas into a collector, but in the field all sorts of difficulties crop out which require great patience and resourcefulness to overcome. Moreover, a volcano is not an easy customer to deal with at close range."

step into a chasm intensely hot, I yet pushed on as soon as I found myself safely over a particularly dangerous-appearing area. I didn't like it, and yet I did.

"I felt like a boy at a circus, for I couldn't take time to study the attraction before me because I suspected something more captivating further on. Nor was I ever disappointed, for nothing was exactly like anything else.

"The broken hills, the falling mountains, the magnificent glaciers, the steaming fumaroles, and the rolling streams can all be described, but their wonderful profusion and the manner in which they encroached upon one another must remain largely in possession of him who is fortunate enough to make a visit to the locality where these things abound in extraordinary splendor."

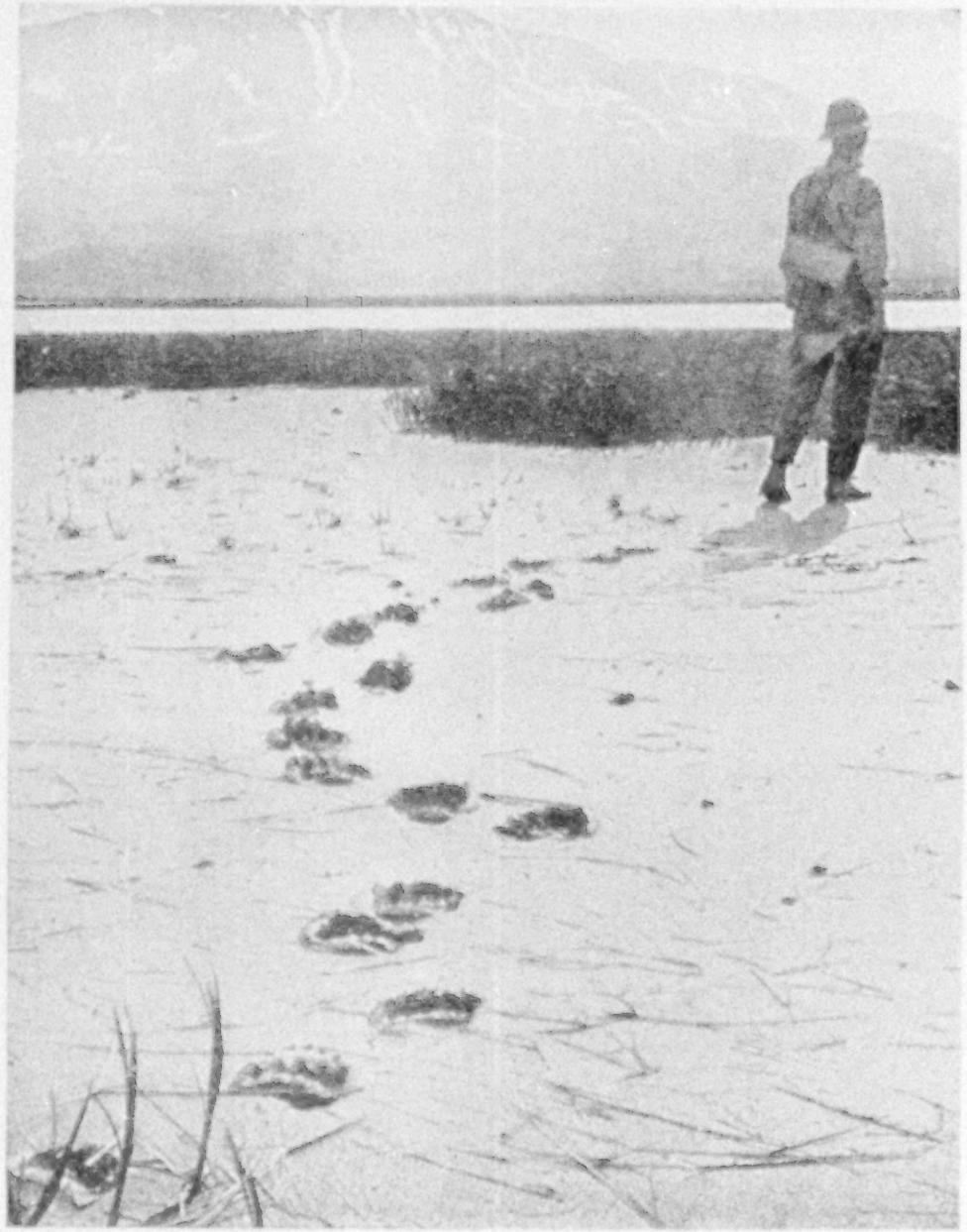
LIKE A HUGE CHEMICAL MANUFACTURING PLANT

L. W. Shipley, Chemist.—"On first entering the valley from between the two guardian volcanic cones, I experienced the same sensation as the man who on seeing a giraffe for the first time exclaimed, 'There ain't no such animal.' The quiet evolution of myriads of columns of vapor from the floor of a wide, desolate valley, the encompassing mountain ridges, the sequestered isolation, the avalanches of rocks, all vividly recalled Sinbad's adventures in the 'Arabian Nights.' It is so unreal.

"Hot streams flow from beneath banks of snow; extensive glaciers hobnob with steaming fumaroles, while icebergs and hot water are found in the same little lake. Enormous mud-flows appear to have run uphill. A stick chars when

A BEAR TRAIL THAT SPROUTED

The fresh tracks in the soft mud caught the grass seed, which blew across the smooth general surface without finding any place of lodgment.



Photographs by Robert F. Griggs

IN THE PATH OF THE KODIAK BEAR

These are the huge tracks of an animal which followed the members of the expedition up the Katmai River valley. They are not the tracks of the bear which Professor Griggs mentions as having crossed the Valley of Ten Thousand Smokes, leaving steaming fumaroles in its wake (see page 129).

thrust into a jet of steam. It is uncannily unreal.

"But the unreality suddenly vanishes when one's foot breaks through the crust and hot volcanic gases rush out. It is also sufficiently realistic to have avalanches of rocks galloping down the 2,000-foot face of Falling Mountain while we are collecting gases in the bottom of a 20-foot hole at its base.

"The familiar fumes of hydrogen sulphide, sulphur dioxide, and hydrochloric acid transform the valley into a huge chemical manufacturing plant roofed over by a permanent cloud of vapors. And when cold and wet, it is rather comfortably lonesome to lean against the hot walls of a sheltered crevice and meditate on the dead bodies of hundreds of flies lying around the orifice of the subterranean chimneys."

A SPECTACLE OF AWESOME MAGNITUDE

D. B. Church, Photographer.—"Regardless of our packs, we hurried down the valley, past the few faint, wispy steam jets that mounted from its floor just over the divide, craning to glimpse the first steam cloud to rise from the valley beyond. There floated over the spur of the ridge to the north a billowy cloud that marked the largest steamer.

"Reaching the higher ground that had hidden my view, I gazed at the panorama before me. Flanked by Mt. Cerberus and Falling Mountain, spread the valley, a maze of pearly columns that billowed skyward and bent before the strong westerly wind. Down a narrow canyon we trudged and climbed out over its painted ash walls onto the valley floor.

"The meager pictures of the previous year, and even the graphic descriptions of Griggs and Folsom, had not prepared me to face such a spectacle of awesome magnitude. I had pictured the valley as large; the actual view dwarfed my wildest imagery to insignificance.

"I started for the nearest fumarole; it seemed a few hundred yards distant. I found it half a mile away. It was a small fumarole and I crept cautiously up to its edge. From its red-painted throat, which vanished deep in blackness, the sulphur-reeking steam roared forth in a smothering blast.

"Passing back, I found a crack in the rock-like crust of the mud-flow, through which sizzled the scorching steam and gas. A few prods with my staff opened a hole into the underground conduit, from which the steam hissed forth. The fragility of the crust and knowledge of the result of a misstep startled me. My fears began to awaken—fears that for several days made me tiptoe over spots where the earth rang hollow beneath my feet. Familiarity gave me greater confidence, but I never ceased to tread carefully the color-daubed regions of subsurface activity.

WORK DROVE AWAY FEAR

"The next day I began my work in the valley. This day the activity and the interest of work drove fear from me. The one conception that pervaded me was: how like this place to Dante's conception of his 'Inferno.' It seemed to me, as we stood on the edge of Novarupta, that this was the Devil's own private corner in hell itself. It seemed, as I gazed at the seething steam clouds that rushed from the cooling lava plug, and at the shattered, steam-smothered furnace that filled the rising vale beyond, that there was some vague, fantastic form, a horrid dream, a hideous, potent 'thing' which was not for human eyes to see nor human ears to hear.

"Then an endless night on the hot, moisture-teeming ground; an endless rolling from side to side to escape the torment of the penetrating heat that seeped up from the hot, sodden ground; and always, as I looked down the valley through the open tent door, shone the marble-like steam columns, which, like tall, writhing specters, swayed in the dim twilight.

"There was always a certain awesomeness about the valley which clung to me throughout my stay. I looked forward with relief to the time when I could put from my sight the curling steamy billows that rose from fumaroles and mounted ever skyward.

"Pictures cannot bring back the Valley of the Smokes. They have lost the awesomeness that lies in the setting. You may build in memory, but never reproduce, the scenes which lie beyond the

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Photograph by Robert F. Griggs

TAKING THE TEMPERATURE OF A "HOT ONE"

Most of the vents were so hot as to be beyond the range of our thermometers; so hot that the steam would char a piece of wood and did not begin to condense for some distance from the orifice.

Katmai Pass. They seem too big to be a part of the rest of the world. They do not seem to connect up with the little things which are built into our lives.

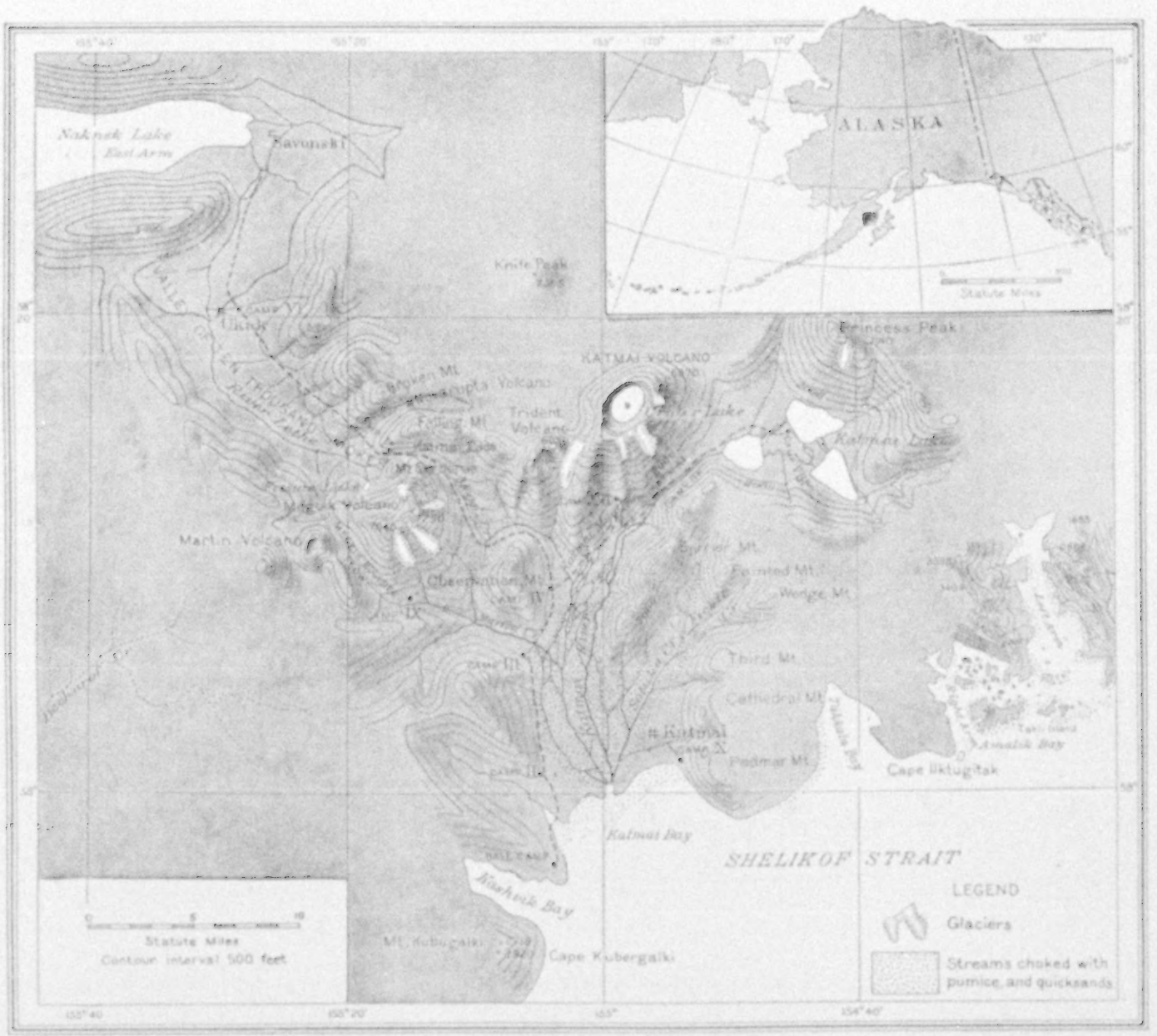
"Outstanding in my memory is the valley as I left it. It was a brilliant day, with puffy silver clouds that floated on a sky of deepest blue and sunlight that glinted on opalescent steam jets and sparkled on peaks fresh-capped with snow.

"As, homeward bound, we skirted Cerberus, the steamers turned in the dying sunlight to shimmering gold and the snowy crests of distant mountains glinted yellow. I forgot the heavy pack which bowed my shoulders as I glanced backward at the growing beauty which filled the valley. Through its giant gateway the 'Valley of the Ten Thousand Smokes' sank from sight as we dropped over the pass, and the sky above reddened to a crimson halo in the fading rays of the sinking sun."

PERSONNEL OF THE EXPEDITION

The organization of the expedition, perfecting details of equipment and supplies, and seeing that they were on the ground when needed, had consumed a large share of the Director's time and energy for more than six months before the departure from Seattle; but the result justified the labor, for the outfit proved adequate to the strain put upon it and enabled us to carry out the work substantially as planned.

There were three problems to be met: First, to secure men who could stand up under the excessive physical labor involved and continue to do the scientific work contemplated, each in his own line; second, so to provision and maintain the expedition as to retain its efficiency until



OUTLINE MAP OF THE VALLEY OF TEN THOUSAND SMOKES

its work should be complete; third, to transport the outfit to the scene of action.

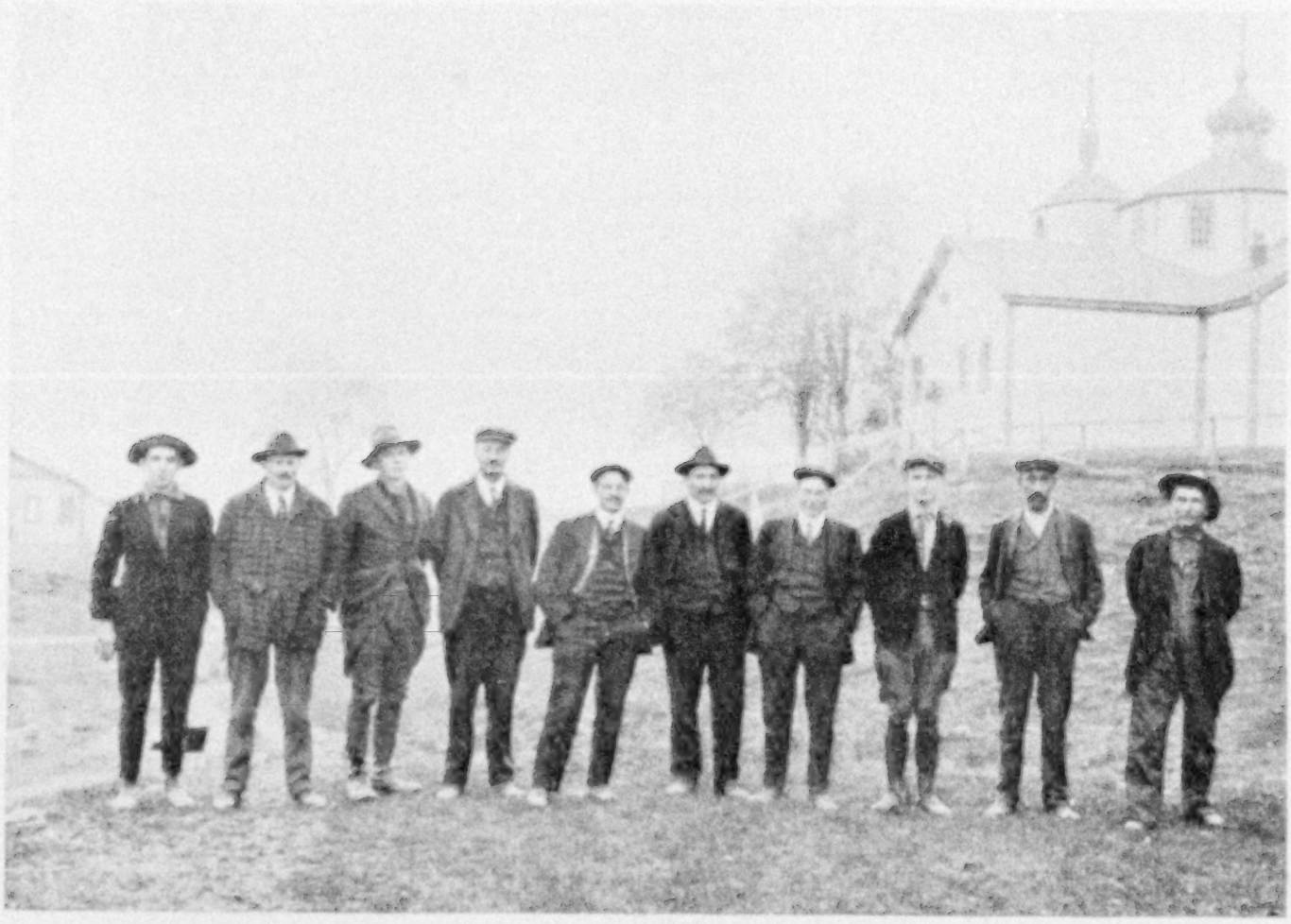
The success with which the first of these problems was overcome is perhaps best attested by the fact that the chief concern of the Director in the field was to hold down the men and prevent them from working so hard as to wear themselves out. There were ten of us, as follows: Robert F. Griggs, Director; Lucius G. Folsom, Assistant to the Director; Clarence F. Maynard, Topographer; James S. Hine, Zoölogist; J. W. Shipley, Chemist; Donovan B. Church, Photographer; Jasper D. Sayre, Assistant Botanist; Paul Hagelbarger, Assistant Botanist; Walter Matroken, Packer; Andrean Yagashoff, Packer.

Without exception, these men worked, each in his own way, to the full extent of his ability for the success of the expedition. The energy, enthusiasm, and self-sacrificing service given to the work were unlimited. The way in which they took hold of tasks, which were always laborious, often very disagreeable, and had usually to be done against obstacles that would have turned back any but the most persevering, proved their worth and won the enduring gratitude of the Director.

ONLY THE MOST CONCENTRATED FOODS COULD BE USED

Previous experience with the conditions around Mt. Katmai made the provisioning of the expedition less difficult.

The limitations of transportation prohibited the use of any of the ordinary canned food, or any food containing water, except at the base camp. Our



Photograph by D. B. Church

MEMBERS OF THE NATIONAL GEOGRAPHIC SOCIETY'S ALASKAN EXPEDITION AT KODIAK, AFTER HAVING COMPLETED THEIR WORK IN THE VALLEY OF TEN THOUSAND SMOKES AND ON MT. KATMAI

From left to right: Jasper D. Sayre, Botanist; Clarence F. Maynard, Topographer (Mr. Maynard was the Topographer of the National Geographic Society Peruvian Expedition of 1915); D. B. Church, Photographer; Lucius G. Folsom, Assistant to the Director; Robert F. Griggs (Chief of Expedition), Botanist; James S. Hine, Zoölogist; J. W. Shipley, Chemist (Mr. Shipley was granted a leave of absence from the Manitoba Agricultural College to accompany the expedition); Paul R. Hagelbarger, Botanist; Andrean Yagashoff, Packer, and Walter Matroken, Packer.

chief reliance was the trusted stand-by of the prospector, bacon and flapjacks. Next came rice, oatmeal, beans, tea, coffee powder, dried apples, apricots, and dehydrated fruits, such as cranberries, raspberries, and strawberries. Lunch consisted of pilot bread, cheese, raisins, kippered salmon, and milk chocolate, for we stopped to cook only morning and night.

As an experiment, I included tinned butter among our supplies. This proved a boon, for it added greatly to the enjoyment of flapjacks and served as a very fair substitute for condensed milk on oatmeal, etc. We could hardly have got along without it in the Valley of Ten Thousand Smokes, where we could fry no bacon. A reflecting oven enabled us to bake bread and biscuits at the lower camps. These proved very welcome, as experience has shown that the lack of bread and butter is a deficiency in the diet so serious as to become almost intolerable after a time.

These provisions proved very satisfactory. All members of the party were in perfect condition throughout the summer. Several of us gained in weight, and one of the boys was 20 pounds heavier than he had ever been before, despite the fact that he had rather more than the average of hard work. On the return there was almost none of that insatiable craving for a change of diet which is apt to develop after a few weeks' use of concentrated rations.

Photograph by D. B. Church

FORDING THE CREEK UNDER THE SHADOW OF MT. MAGEIK

The waters of this stream were swift, but shallow, and presented no dangers in crossing, fears of quicksand proving ungrounded. All supplies for the stay in this valley had to be man-packed from base camp, and obstructions like this creek presented many difficulties for the heavily laden members of the expedition, even though the element of personal peril was not always present.

CARRYING IN SUPPLIES ON MAN BACK

The problem of transportation was in a way the crux of the whole situation, for everything else depended on its solution. We considered pack-horses, but the difficulty of landing them through the surf, of providing fodder in the devastated district, and of managing them in quicksands and bad lands made them seem impracticable. We therefore fell back on the most primitive of all means of transportation — man-back packing. Every member of the expedition understood from the start that he was to be pack-animal first and scientist second, and all stood up under the strain of labor, to which several of them were quite unaccustomed.

The plan of operation was to proceed half a day's march from camp, establish a new camp at the terminus, from which two men explored the country round about, while the others brought up supplies, returning each night to the starting point till a sufficient quantity had been accumulated to permit another move forward. By thus moving short distances the packers were able to dispense with all duffle, carrying freight exclusively, and the heaviest consumption of food was kept behind the front.

Perhaps the best way to convey an impression of the labor involved in such procedure will be to state the cost. We found that by the time a 50-pound sack of flour had been carried into the Valley of Ten Thousand Smokes it had cost us $17.50.

LANDING THROUGH THE SURF

In previous years we had landed near Katmai village, on the north side of the

Photograph by D. B. Church

THE TRAIL UP TO KATMAI PASS

The way led over permanent snow-drifts, for the snow had been covered with ash during the eruption of Mt. Katmai, and this coating protects the drifts from the sun's rays. All the supplies for the camp had to be carried laboriously on the backs of the men through this pass into the valley.

bay, taking the shortest route to the volcano. But in 1917 we landed on the south side, near Kashvik Bay. Here we found a beach which, while apparently exposed to the storms, was in reality so protected by an offshore reef as to be much safer than Katmai beach, affording the best landing for many miles along the coast. Even as it was, however, one of the dories carrying our stuff to the ship on the return was nearly swamped, so that our outfit was considerably damaged by salt water.

FIRST SIGHT OF MT. KATMAI

By landing to the south of Katmai Bay, we had the added advantage of being able to place our base camp in a district unaffected by the eruption, for this area lay to one side of the great ash cloud which was carried to Kodiak on the west wind. This fact enabled us to carry on important biological studies in the comparison of devastated with undevastated country, which our situation had precluded on the previous expeditions.

Our first sight of Mt. Katmai came the day after we landed. Familiar as I was with the volcano from the work of the two previous seasons, its enormous size struck me as a new surprise. Here from a distance of over 20 miles the mountain loomed up so much bigger than the nearer mountains as to dwarf them. The great jagged edges impressed us all with a new conception of the immensity of the crater within.

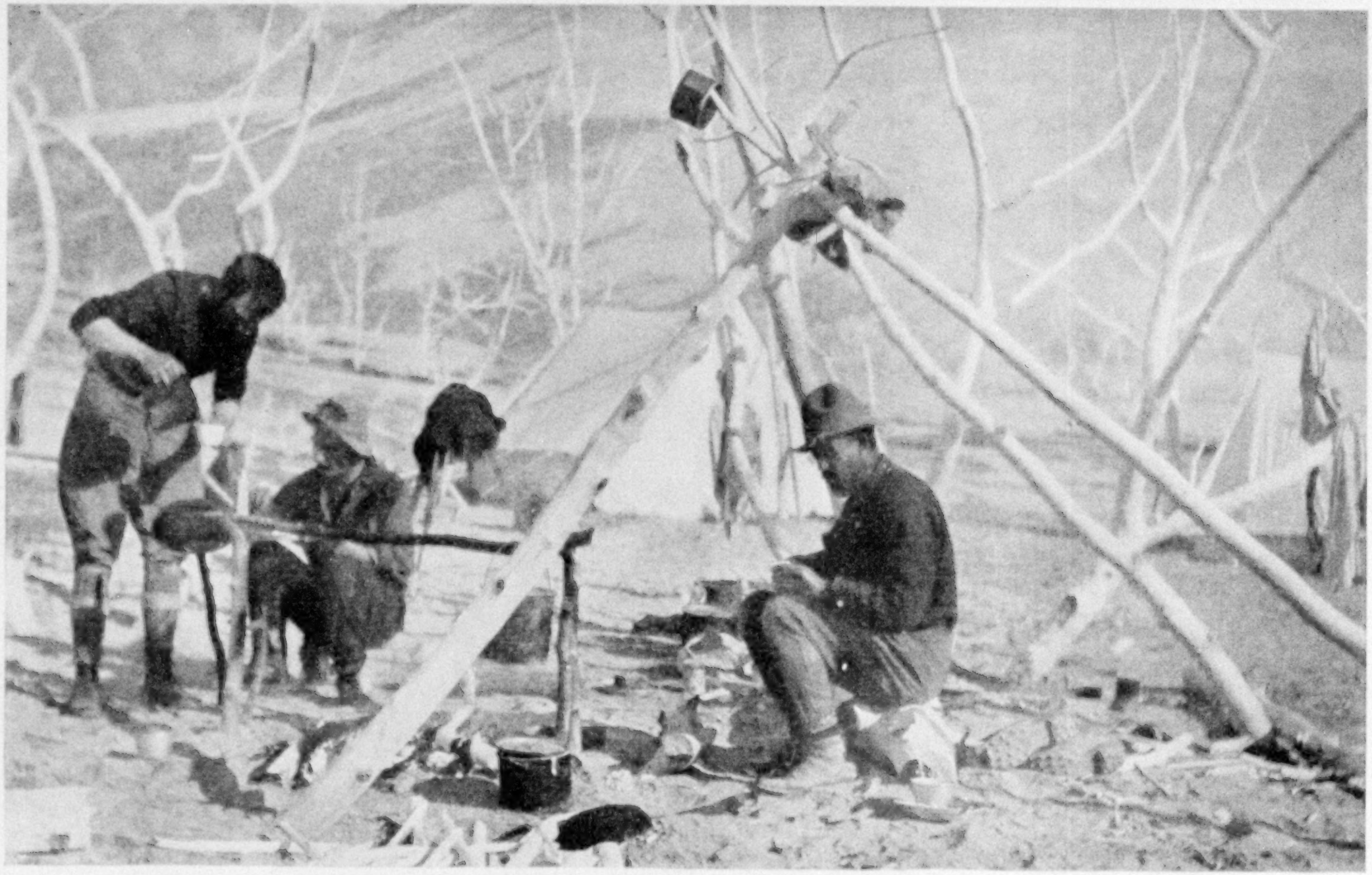
Some of the new members of the expedition, seeing the volcano for the first time, accused me of not having given a correct impression of it in the article of 1917. They had not expected anything nearly so big. As I looked at it, standing three or four times higher than the clouds which drifted up the valley, I could not restrain a feeling of pride that

A CONICAL ROCK PILE ON THE SURFACE OF THE MAGEIK BOULDER FLOW

Photographs by D. B. Church

ONE OF THE LARGE ROCKS CARRIED DOWN IN THE MAGEIK BOULDER FLOW

This phenomenon resembled a great landslide. Coming down the mountain, the mass of rock and soil made a right-angle turn into the valley like a stream of water (see page 161)



Photograph by J. W. Shipley

ENJOYING A FLAPJACK FEAST IN CAMP AT THE BASE OF MT. KATMAI

Flapjacks were a treat to the members of the expedition, for during their stay in the Valley of Ten Thousand Smokes griddle and frying-pan cookery was impossible, owing to the absence of wood. Here cottonwood trees were plentiful, but it was a ghostly forest, as all vegetation was killed by the shower of ashes which fell when Mt. Katmai exploded and erupted six years ago.

I had actually stood on the rim of that tremendous pit and looked down into the caldron below.

The first camp established up the valley was at the mouth of Martin Creek. From this base a party was sent to explore Martin Valley and Martin Volcano. [This interesting volcano was discovered by the 1915 expedition of the National Geographic Society, see pages 33 and 34, NATIONAL GEOGRAPHIC MAGAZINE, January, 1917.]

We were disappointed in our expectation of examining the crater of Mt. Martin because of the weather. We waited for several days, both on the way up the valley and on the return trip, but without success. At the beginning of the season it was left till later, and on the way out a week was reserved for exploration; but this proved insufficient, for the clouds never lifted until several days after we had had to pack up and come away without having so much as attempted the climb, because of the approach of the time for the boat to come and take us back to civilization. As the event proved, we would have had to wait fully ten days before the climb would have been possible. Only once while we waited did we have so much as a sight of Mt. Martin. One morning the clouds lifted for about an hour, so that we were able to secure some long-range pictures, but before we were ready to try the ascent they had closed down again and we had to abandon the attempt.

But, though disappointed in our hopes of exploring this volcano, we found in another feature abundant reward for the time spent in the vicinity.

ANOTHER CONVULSION OF NATURE

For at the head of Martin Creek is one of the most interesting phenomena of the whole volcanic district—what, for want of a better term, I have called the "Great Mageik Boulder Flow"—a third wonder, almost worthy to be ranked along with the crater of Katmai and the Valley of Ten Thousand Smokes. When I say that a mass of rock and soil containing boulders as big as a house flowed like water down a valley, I shall probably be classed with Münchausen, the prince of liars; but, fortunately, these are the days of the camera and I can prove my assertion.

During the eruption, quite possibly coincident with the bursting forth of Martin and Mageik volcanoes, the whole face of a mountain let go and flowed down into the valley, carrying destruction to everything within its reach. It was a real example of one of those great and sudden "convulsions of nature" of which one reads so much in the older literature, but of which he sees so little evidence in the world about him; for even in a volcanic district most phenomena clearly belong to the regular order of nature.

But here, for once, is a formation so remarkable as to make it appear at first sight that the ordinary laws of nature were suspended during its formation.

Rocks, exceeding ten feet in diameter, are abundant in the flow, which in some places is made up almost entirely of such big boulders without any mixture of finer materials. Much larger rocks are by no means uncommon. We found many reaching 30 or 40 feet in length. The largest single stone we observed was about 50 feet long, 20 feet wide, and 20 feet high, lying largely concealed in the mass of detritus (see page 159).

It seems incredible that a body composed so largely of angular rocks could by any means have acquired such a high degree of fluidity as is shown by this mass, but in view of the fact that it turned a corner in the valley and adjusted itself to the irregularities of its bed, one is compelled, in justice to the facts, to recognize that its motion was more of a flow than a slide.

Nowhere can one form a reliable estimate of its thickness, but over much of the ground it must exceed 100 feet. The total mass of materials moved was therefore stupendous.

At the extremity it is composed mostly of chunks of the old peat soil, which originally covered the mountain side with only small quantities of rock fragments. Boulders are more numerous a little back from the tip, and in places the terrain is composed exclusively of broken stone over considerable areas.

One of the most curious features is the character of the surface, which lacks entirely the hummocky appearance typ-

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ical of the ordinary landslides, but instead is covered in many places by regular, steep-sided, conical piles of material. Some of these stand isolated; others are thickly grouped. Since their slopes stand at the "angle of repose," it is probable that they were formed by the shaking down of more irregular masses (see page 159).

THE ASCENT OF KATMAI

After the successful ascents of 1916, we considered the climbing of Katmai itself a secondary matter. The main object in making the climb on the 1917 expedition was to survey the crater, ascertain its dimensions, and to secure better pictures of the abyss. Remembering our previous difficulties with soft, slippery mud, we decided to leave the ascent until late in the season, after the winter's snow had melted and the mud had had time to dry up somewhat.

Days for climbing the high mountains were very few in 1917, and we had to wait in idleness for a full week before there came any chance to try. Even then we were cheated, for the clouds began to gather as we ascended and completely shut down just as we reached the crest. We had one fleeting glimpse of the crater, but before we could so much as set up a camera it was gone, and we had to wait three days more before there was another chance to make the climb.

Our decision to defer the ascent till late in the season was well founded, for in places where the year before we had floundered up the slopes in slippery mud ankle deep we found the ground hard and firm, so that the climb, which before had taxed our strength and endurance to the very utmost, was now made easily in four hours, even under 30-pound packs. Those who had not gone through the previous experience had difficulty in believing that the climb could have been so much harder until we came upon our old trail, broken so deeply into the mud that it persisted sharp and clear for a long way, so that every one could see for himself how he was traveling easily over firm ground, where before we had plowed along ankle deep in mud.

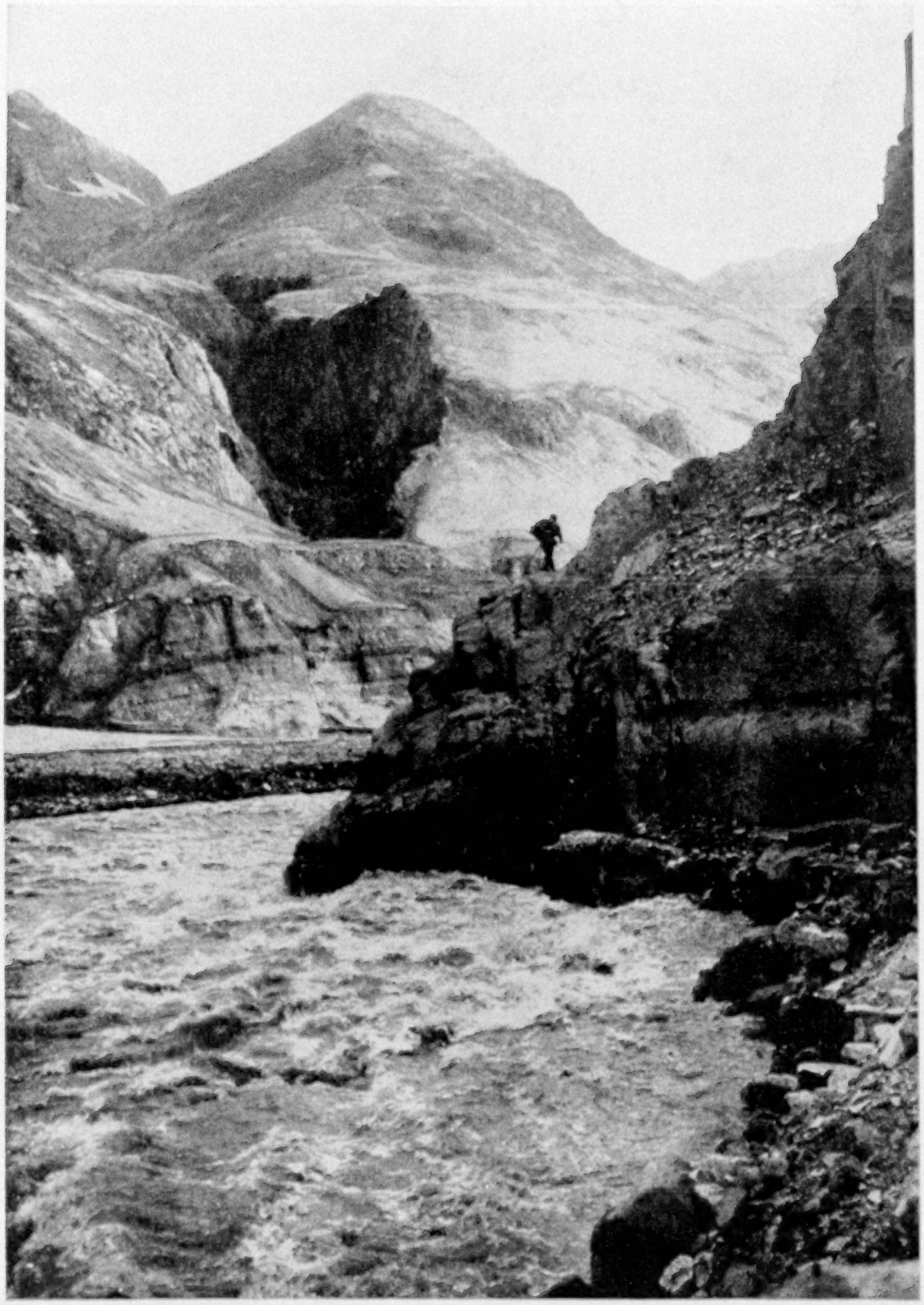
This was only one of the many frequent examples we had of the difference between doing a thing for the first time and following along after the path is broken. I have no doubt that some day our accounts of the difficulties we encountered with the limited facilities at our command will appear incredible to those who may tour the district provided with all the facilities and comforts of modern travel. It seems to me entirely practicable, for example, for any one to ride up to the very rim of the crater astride a horse. All that is needed is the organization necessary to furnish the horse and the fodder.

AN ABYSS OF INCONCEIVABLE SIZE

In spite of the disappointment on the first attempt, every one of the party was enthusiastic over the crater, and all agreed that the single glimpse we had before the clouds shut in was ample reward for the climb. Some members of the party indeed thought the sight more beautiful and wonderful than the Valley of Ten Thousand Smokes itself. The party were unanimous in the opinion that the photographs convey no idea whatever of the vast abyss. Without the colors and with nothing to indicate the scale, to give more than a hint of the real character of the phenomenon is impossible. Like the Grand Canyon and other sublime marvels of nature, the crater must be seen to be appreciated.

But even when one stands on the rim and looks down, he can gain no conception of the real magnitude of the crater. It is so far beyond any one's powers of perception that the wonder comes back to him and grows with each visit.

I found myself surprised at the crater's grandeur, in spite of my experience of the previous year, for it was far more sublime than I had remembered it. One reason why the magnitude of this volcano is so hard to grasp is that the proportions are so perfect that no one dimension appears exaggerated at the expense of the rest. If the crater were not so deep, the area would be more evident; if the walls were not so precipitous, one could better measure with his eye the distance to the bottom. But as it is, one can only realize that the immensity of the awesome abyss is far beyond the grasp of his mind.



Photograph by D. B. Church

CLIMBING OUT OF KATMAI CANYON

The wall opposite is as high as parts of the Grand Canyon, as beautifully colored, and as precipitous (about 4,500 feet). This is one of the many natural wonders of surpassing grandeur in the Katmai volcanic region which have been made known to the world through the explorations and discoveries of the four National Geographic Society expeditions.

Photograph by D. B. Church

THE ONLY HOOKS USED IN CATCHING THESE SALMON WERE HANDS

In a small creek which runs into Katmai Valley the members of the expedition found these four and five pound fish which had come up into fresh water to spawn. They were easily caught by the tail in the shallow pools.

Photograph by J. W. Shipley

CARRYING GRASS FIVE MILES INTO THE DESERT FOR THE SAKE OF AN EASIER BED

Some of the members of the expedition had not the foresight to provide such mattresses; their blankets, therefore, were spread upon pebbles. This was Camp Four, the last camp before entering the Valley of Ten Thousand Smokes (see map, page 155).

Photograph by J. W. Shipley

WORK OF THE GREAT FLOOD IN THE KATMAI VALLEY

A stream flowing between Katmai Volcano and its neighbor had piled up an immense dam across the valley. Behind the dam a vast lake accumulated. Then the dam burst and the torrent, like a Johnstown flood, rushed seaward. For miles, where thick forests had stood, the trees were sheared off at the surface of the ash. The few trees which remained were bent, twisted, splintered, and broken in every describable manner (see the story of this flood in the January, 1917, GEOGRAPHIC).

Photograph by D. B. Church

A CHEMICAL LABORATORY IN THE KATMAI REGION

Only a chemist can understand the difficulties of making quantitative analyses where one must carry his laboratory on his back

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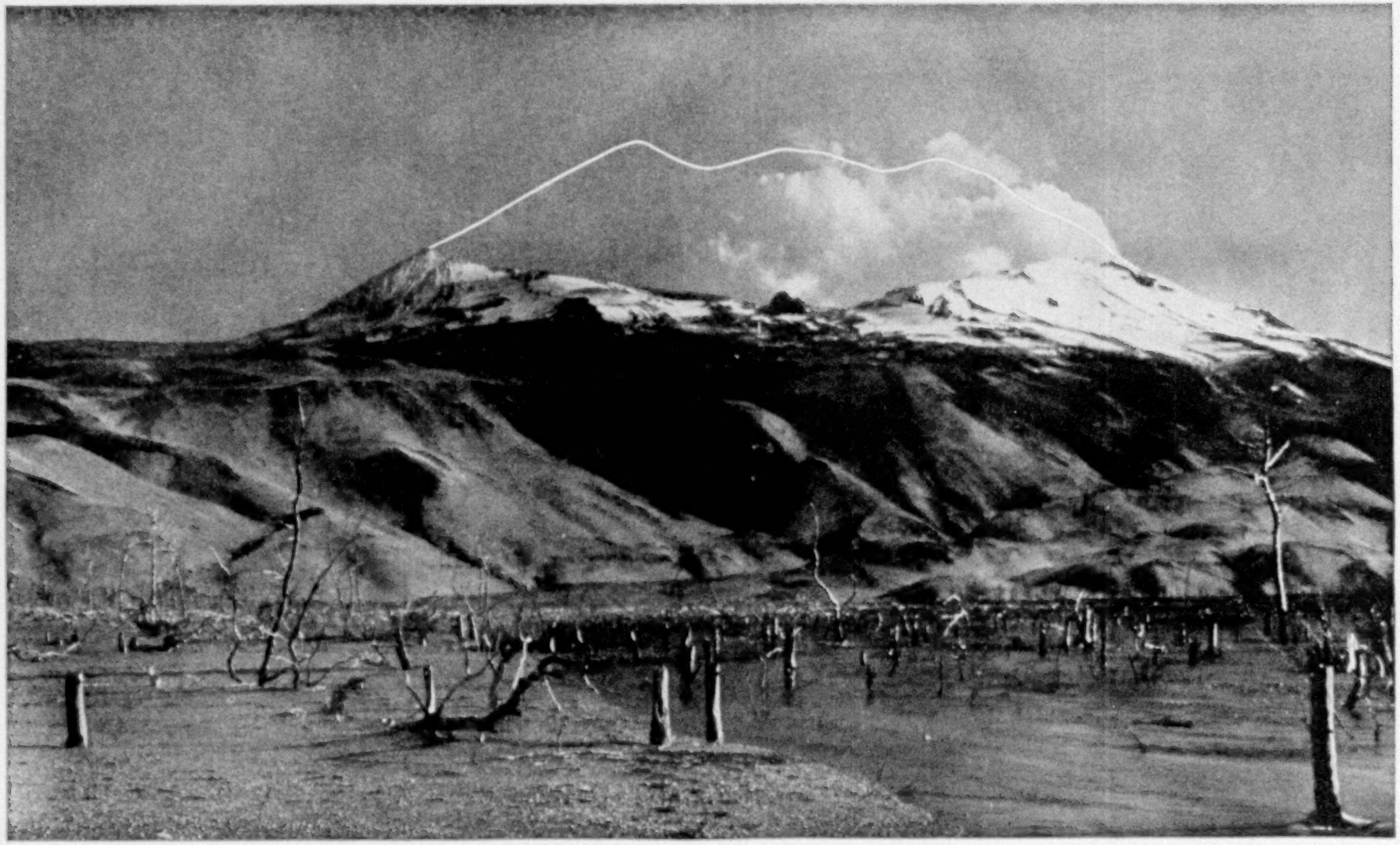
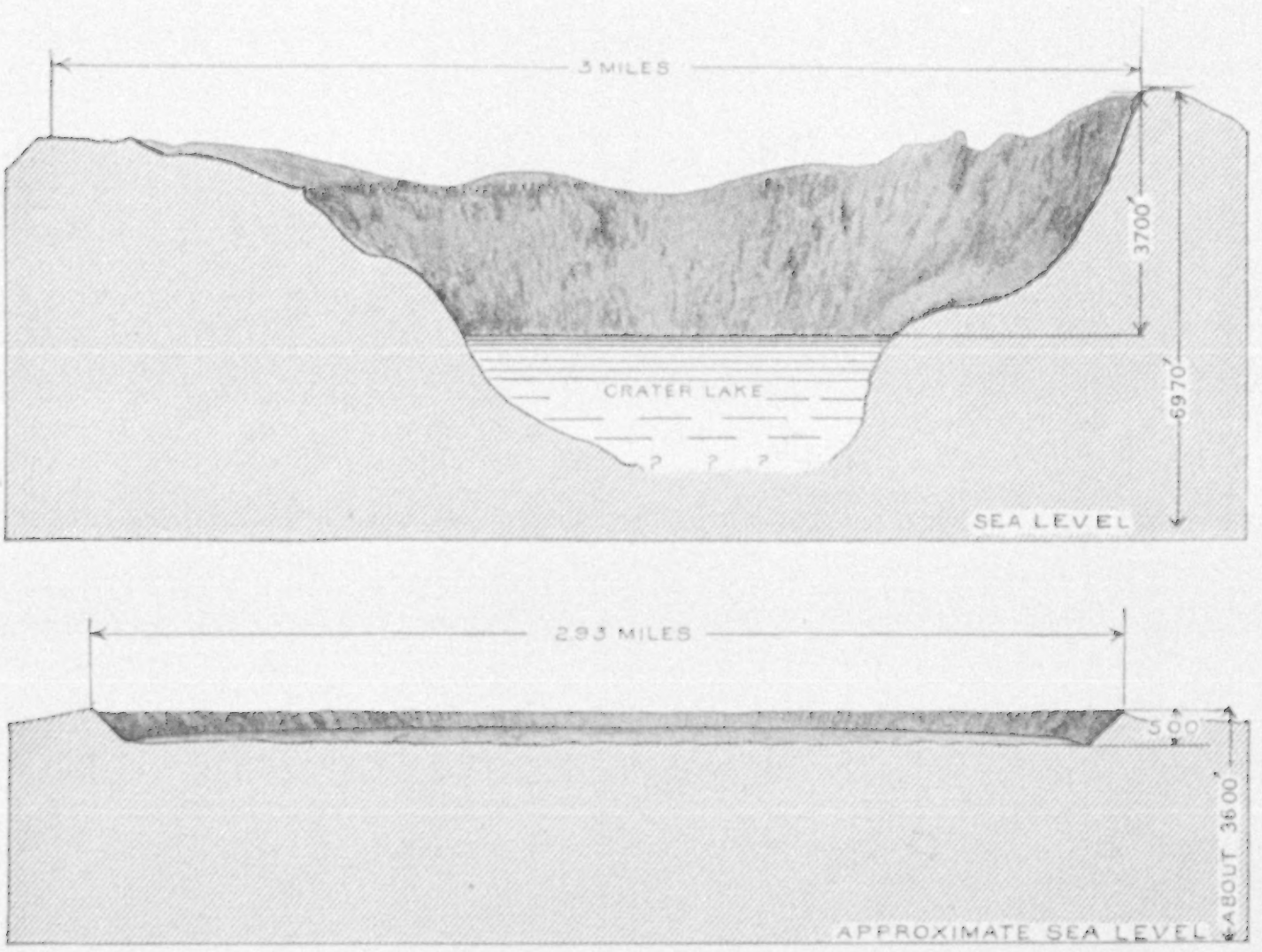


Photograph by Robert F. Griggs

MT. KATMAI, TITAN OF VOLCANOES: ALASKA

The eruption of Mt. Katmai, in June, 1912, was one of the most tremendous volcanic explosions ever recorded. A mass of ash and pumice whose volume has been estimated at nearly five cubic miles was thrown into the air. This left Katmai as it is shown here, the mere stump of its former self; the white line indicates approximately the original height of the mountain. The great arc shown in the photograph is the rim of the gigantic crater within. The peaceful steam clouds now floating up from the crater, compared with the devastating blast which completely disemboweled the mountain, are like the wisps of smoke which come from the cannon's mouth after the projectile has been fired.



THE KATMAI CRATER (UPPER) COMPARED TO KILAUEA CRATER (LOWER)

Until the National Geographic Society explorations, Kilauea of Hawaii had been considered the greatest active crater on earth, but it is now proven to be far exceeded in size by the world's youngest of volcanic vents, the Katmai crater, which is not yet six years old (see page 168).

Knowing that the size of the volcano was beyond my powers of comprehension, and having no means of ascertaining the dimensions, I did not dare in 1916 to report my real judgment of its depth, for fear that in the excitement of the moment I should have made some wild exaggeration that would put me in an embarrassing position when the actual dimensions were obtained. The facts prove that even our largest estimate of depth was far short of the truth!

I dared not then make any comparisons with the other great craters of the world; but now, with the data of Maynard's accurate survey at hand, such a comparison furnishes the best means of conveying an impression of the magnitude of Katmai itself.

DIMENSIONS OF THE CRATER

The survey shows that the width of the crater rim, as seen from below, which includes all of the concavity on top of the mountain, is 3 miles. The circumference, measured along the highest point of the rim, is 8.4 miles. The area is 4.6 square miles. The precipitous abyss, which does not extend to the rim on the southwest side, is somewhat shorter, measuring 2.6 miles in length, 7.6 miles in circumference, and 4.2 square miles in area. The milky blue lake in the bottom is 1.4 miles long and nine-tenths of a mile wide, with an area of 1.1 square miles. The little crescent-shaped island in the lake measures 400 feet from point to point. The precipice from the lake to the highest point of the rim is 3,700 feet.

Photograph by Clarence F. Maynard

KATMAI, THE GREATEST ACTIVE VOLCANO IN THE WORLD

If every skyscraper, department store, tenement-house, theater, and residence—every structure reared by man—in Greater New York were dumped into the Katmai crater, there would still be a yawning abyss twice the size of Kilauea, in the Hawaiian Islands, until now considered the greatest active volcano in the world.

The cubical capacity of this stupendous hole is no less than 4,500,000,000 cubic yards. Into the crater 900,000,000,000 gallons could be poured. This is more than four times the total capacity of the Ashokan and Kensico reservoirs, from which Greater New York now receives most of its water, and the Schoharie reservoir, which is to be constructed. New York City uses 550,000,000 gallons of water daily. Katmai crater once filled could supply the American metropolis for 1,635 days.

But even these figures do not tell the whole story, for they do not include the amount of rock that was blown off from the mountain during the brief sixty hours of its explosive activity. There must be added the material in the peak above the level of the present crater rim.

The figure then arrived at is 11,000,000,000 cubic yards. This is over forty times the amount of earth and rock removed in the construction of the Panama Canal.

KATMAI, THE GREATEST ACTIVE CRATER IN THE WORLD

Kilauea, in the Hawaiian Islands, has always been accounted the greatest active crater in the world, but it is clear that it must now yield the palm to Katmai. Kilauea's greatest diameter is 2.93 miles, its circumference is 7.85 miles, and its area is 4¼ square miles. These dimensions are slightly smaller than the corresponding ones on Katmai. The great difference is in depth, Kilauea's greatest depth being 500 feet, while Katmai's is 3,700 feet.

Of craters no longer active, only two surpass Katmai in dimensions: Crater Lake, in Oregon, measures 4 miles wide by 6 long, while Haleakala, in Hawaii, has an area of 19 square miles. But while Katmai is somewhat inferior to these in size, yet because of its proportions it is a far grander spectacle to look upon; for in both Haleakala and Crater Lake the cliffs surrounding the pit

are so much lower comparatively as to make their craters inferior to Katmai, from a scenic point of view. The tremendous depth more than any other feature impresses the beholder of Katmai.

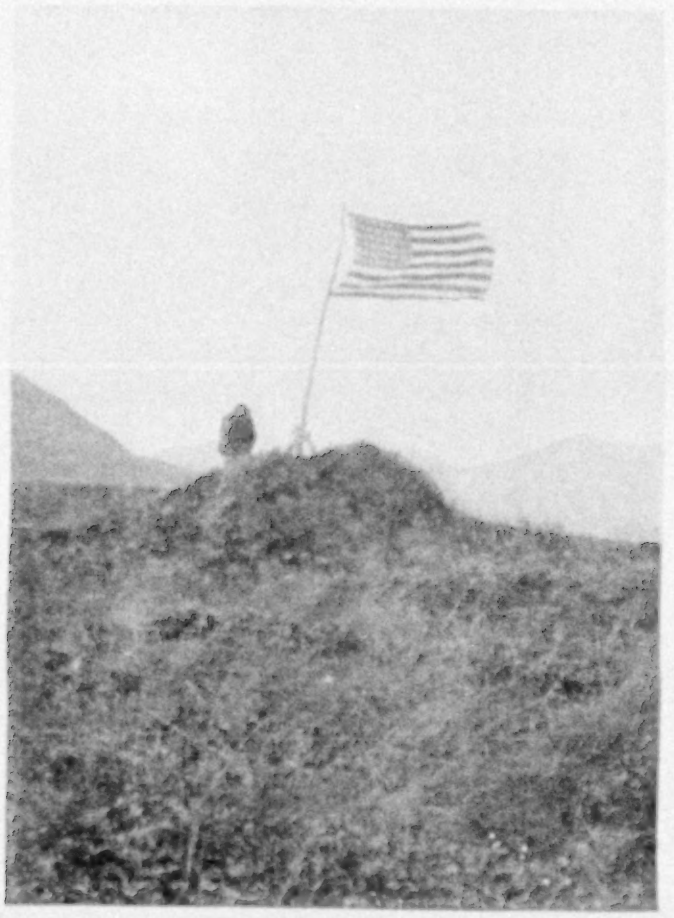
Moreover, if one recalls the fact that the beautiful blue of the Katmai lakes and the wonderful canyon of Katmai River, which is almost as deep as the Grand Canyon, lie in full view from the crater rim, he will recognize that for sublimity of scenery this place has no equal in the whole world.

ALL OF THE BUILDINGS OF GREATER NEW YORK WOULD NOT FILL THE CRATER

Statistical comparisons of objects, so far from the experience of most people, can give, however, no conception of their real magnitude. Our comparisons must be with objects and places within our every-day experience. As I sought for some familiar object big enough to serve as a basis of comparison with a hole of such enormous dimensions, I remembered the experience of my first attempt to see New York City afoot. I can never forget my bewilderment at the endless rows of closely built blocks, series on series, and how I found myself physically exhausted long before I had begun so much as to inspect the city in detail.

Here, then, is an almost inexhaustible supply of objects, large enough to serve as units for the measurement of cubic capacity of almost unlimited dimensions. If one could pick up the blocks of buildings of New York one by one and drop them into the crater of Katmai, how many would be required to fill it?

The truth is that if a typical New York tenement block should be set bodily into the crater of Katmai it would be but a drop in the bucket. But the tenement houses are relatively insignificant in comparison with the skyscrapers of lower New York. How would they appear in the crater? One must answer that it is doubtful whether all of the skyscrapers of New York together would fill the lake at the bottom of the abyss.



Photograph by Paul R. Hagelbarger

OUR FLAG, WHICH FLEW ALL SUMMER FROM THE LOOKOUT AT BASE CAMP, BY THE SEA

If one could imagine himself really trying to fill the crater with the buildings of New York he would find that if he dropped them in, block by block, the task would be so long that he would soon want to begin operations on a larger scale, cutting off bigger and bigger slices of the city, as he worked up town.

Even so, he would be astonished at the capacity of the hole, for after he had made a clean sweep of Manhattan Island he would find that he had only begun on his job! He would have to cross the river and continue through Brooklyn, then take the Bronx, and all the other boroughs of Greater New York. And if every single structure erected by man in this great city were deposited in the crater they would by no means fill the vast abyss. On the contrary, the hole that remained would still be a good deal more than twice as large as Kilauea!

XUM

NATIONAL GEOGRAPHIC SOCIETY

SINCE ITS FOUNDATION, thirty years ago, the National Geographic Society has been responsible for many notable achievements in the realms of discovery, exploration, and conservation.

Its Peruvian expeditions resulted in the discovery by Hiram Bingham of the Lost City of the Incas, Machu Picchu, the great capital which was the seat of power and culture of a remarkable civilization that flourished in the Western Hemisphere for centuries before the coming of Columbus.

It assisted in financing the expedition of Rear Admiral Robert E. Peary, which discovered the North Pole.

Its contribution of $20,000 saved from destruction a wondrous forest of giant sequoias in California, and gave it to the American people as a part of our national-park system.

Now come the discovery of the Valley of Ten Thousand Smokes and the survey of Katmai, the world's greatest active volcano—achievements which will rank with the foremost contributions to world geography in modern times.

Each of the 650,000 members of the Society will experience a feeling of pride and satisfaction in this latest accomplishment, for it was their financial support of the organization's aims, "the increase and diffusion of geographic knowledge," that made possible the equipment of Robert F. Griggs and his intrepid associates for the task which they have performed with signal distinction and success.

HELPING TO SOLVE OUR ALLIES' FOOD PROBLEM

America Calls for a Million Young Soldiers of the Commissary to Volunteer for Service in 1918

By Ralph Graves

MRS. MULVANY with her pet pig is no longer an object of ridicule and a topic for jest. She is a patriot. The Solomons of conservation are sending Mr. Average Consumer to her as a model of thrift, just as the Wise Man of Biblical times sent the sluggard to the ant. By means of her pig Mrs. Mulvany is helping to win the war, for she is making from one to two pounds of pork grow each day where none grew yesterday.

"Go thou and do likewise" is the plea of the officials of the U. S. Department of Agriculture, upon whose shoulders rests the burden of educating the American public to the necessity for the production of millions of pounds of additional food-stuffs in order that the armies of liberty—American, French, British, and Italian—may be kept efficient on the battle-front and in the training camp.

Mr. Mulvany calls Mrs. Mulvany's pet "the gintleman that pays the rint," while throughout the Middle West, since the pioneer days, the porker has been known as the "mortgage-lifter." For the last eight years the pig has occupied an increasingly important place, both in the economy of the farm and of the village household, and has been a stimulus to the productive activities of thousands of boys who have organized "pig clubs."

The members of these and related agricultural clubs have recently received a new designation of tremendous significance—soldiers of the commissary. There were 45,000 such soldiers in the pig divi-

sion of the commissary army in 1917—an army whose total strength (corn clubs, potato clubs, poultry clubs, sheep clubs, calf clubs, and canning clubs) was well over half a million.

This year an army of one million is needed. It must be a volunteer, not a conscript, army, and the age limit is from 10 to 18 years. Recruits will not be confined to the farm districts; enlistments are equally desirable from towns, villages, and the suburbs of our great cities.

What has been accomplished by America's youthful commissary army is a story of surprising and stimulating interest, an incentive to redoubled effort during the next nine months, when every ounce of meat produced, every bushel of grain, every can of vegetables, every pound of wool, will have a direct and potent bearing upon the length and conduct of the war.

POPULAR PREJUDICE WITHOUT FOUNDATION

Just as the aviation service, more than any other branch of the army or navy, exercises an irresistible appeal to young Americans eager to join the fighting forces of the United States, so the pig clubs are exercising a peculiarly strong appeal to the boys and girls of the country. The result will not be transitory and for the immediate necessities only. In fact, the direct and indirect effects of the pig-club movement throughout the South, where it originated less than eight years ago, have been so salutary that the United States Government, even before the emergencies brought about by the war, inaugurated a widespread campaign to encourage and promote the extension of the work.

One of the first and most essential steps to be taken in the effort to increase the number of pig fanciers and enthusiasts is a campaign of education to disabuse the public mind as to the habits and nature of pigs. Few domestic animals have been so persistently maligned and with so little reason.

Instead of being the unclean, insanitary creature almost universally depicted, it is the testimony of those who know the pig best that it is one of the cleanliest of animals, surpassing the dog in this respect. It is true that many towns have ordinances which prohibit the keeping of pigs within their corporate limits, but these restrictions have been the outgrowth of the carelessness and negligence with which pigsties have been tended in the past. When given the same care which customarily is observed in keeping the stalls of horses and cows in proper condition, pigsties are far more sanitary and less odoriferous. A pig, given a bed of straw, will keep it clean, in striking contrast to the habits of horses and cows in stalls.

Those who appreciate the value and importance of the "keep a pig" movement and are anxious to foster the substitution of pigs for dogs as pets have begun campaigns in many communities to procure a modification of town ordinances which will permit the raising of a pig or pigs on premises where careful sanitary regulations are strictly observed.

There are more than 10,000,000 boys and girls in the United States between the ages of 10 and 18 years. It is an extremely reasonable ambition on the part of the Department of Agriculture to enlist one-tenth of this number into active service as food-producers, supplementing and coöperating with the farmers and the housewives in their essential labor of increasing the supplies so vitally needed in the present emergency.

THE BEGINNING OF PIG CLUBS

It was in the fall of 1910, in Caddo Parish, Louisiana, that a rural schools superintendent, E. W. Jones, originated and organized the first boys' pig club. It was a modest beginning, with 59 boys, who were in a quandary as to the best method of disposing of the crops which they had harvested in their corn-club activities. The pioneer pig-club promoter conceived the idea of affording the boys an opportunity of realizing a profit not only on their corn crops, but a feeder's profit on the grain as well.

When this movement began a pure-bred pig was a rarity in the South. The "razor-back," shifting for itself in the pine barrens and leading a "root-hog-or-die" existence while ranging over exten-

Photograph from Department of Agriculture

GROOMING A PIG FOR THE STATE FAIR

Eight years ago, before the inauguration of the pig-club movement in the South, most of the hogs in that section of the United States were of the razor-back variety—the kind which is so thin and scrawny that a wag has declared the farmer can prevent its going through a hole in his fence by tying a knot in its tail.

sive palmetto shrub tracts, was the only type of pig familiar to the farmer. To-day blooded swine are the rule rather than the exception, and it is a high tribute to the educational value of the boys' pig clubs that of the four States—Mississippi, Georgia, Virginia, and Delaware—reporting an increase in swine population on September 1, 1917, over the same date in 1916, Mississippi and Georgia stand second and third in pig-club enrollment. These two States reported an increase of 90,000 hogs, while the country at large showed a decrease of 5,000,000.

One of the strongly emphasized slogans of the pig-club organizers and supervisors is that it does not pay to raise a poor hog. On the other hand, the profits to be derived from pure-bred pigs are exceptionally large, considering the amount of capital invested. This preachment not only has had its immediate effect in pig-club communities, where example has taken the place of precept, but it is causing the farmer to awaken to the fact that his son and his daughter are proving more efficient than he, simply because they are taking advantage of the information which has been gained by experts and specialists through years of experimentation and research.

THE "PRACTICAL" FARMER *vs.* THE PIG-CLUB MEMBER

The "theorists," as the college-trained agriculturists were once called, are no longer scorned by the "practical" farmer, whose "practicality" is seen in a very unenviable light when he is compelled to admit that it takes two years for his range-reared hog to acquire a weight of 150 pounds, while a pig-club member, like young Walter Whitman, of Indiana, presents as an exhibit his pet Duroc.

Photograph from C. C. French

BEING BROUGHT UP ON THE BOTTLE

A foundling of the sty finds a solicitous guardian in this member of a Texas pig club. The hungry little wee-wee will reward its master by proving a most interesting and harmless pet, and when it has outgrown its playful ways it will enrich the family larder and the boy's purse.

which gained 18 pounds, 21 pounds, 27 pounds, and 24 pounds in four consecutive weeks.

When Walter's pig was six months and seven days old it weighed 297 pounds, and on its eighth-month birthday it tipped the scales at 456 pounds. The average daily gain was 2.35 pounds, at a cost of nine and one-tenth cents a pound. George Barker, of Yeddo, Indiana, has a record of a daily gain of 2.24 pounds for his pig, at a cost of seven and three-tenths cents a pound, while the pig of Samuel Evans, Brazil, Indiana, gained two pounds a day during the feeding period, at a cost of six and two-tenths cents a pound.

In the Southern States, where pasturage is more abundant and dependence upon corn for fattening food is not so great, the cost of gain per pound is less.

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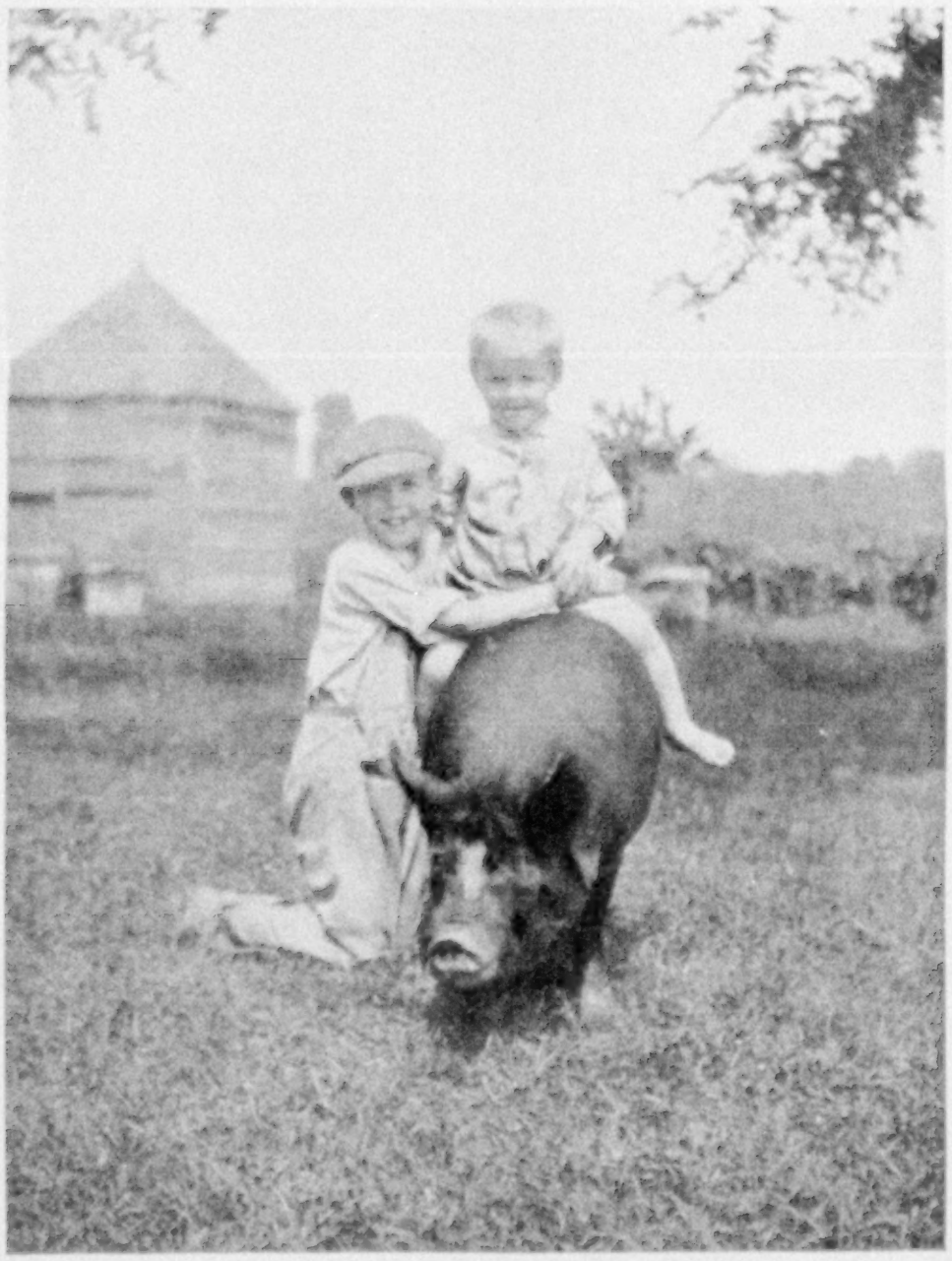


ASTRIDE TWO HUNDRED POUNDS OF SEVEN-MONTHS'-OLD PIG

One of the by-products of the boys' and girls' club movement throughout the United States is the instilling of a love of animals, which will result in young people taking a greater interest in farm life.

BANKERS FINANCE PIG-CLUB BOYS

One of the most interesting developments of the pig-club movement has been the establishment of cordial business relations between bankers and boys who want to raise pigs. There are bankers in practically every State who are glad to supply club members with the necessary funds for their start as pork-producers. The State of Arkansas furnishes a typical example. Last year the bankers of that Commonwealth financed 2,400 boys and girls out of the total pig-club membership of 2,700.

Not only have such loans proved to be "gilt-edged" from the financier's standpoint, but they have been a direct source of increased revenue and business for the bank. A Texas banker recently bought 326 pigs for club members in his county and was able to trace $75,000 direct increase in his deposits as a result of the cordial relations established with the successful club members and their families.

In financing pig clubs the bankers cooperate with the joint representative of the State agricultural college and the U. S. Department of Agriculture, known as the State extension leader, who designates a pig-club agent to organize a county club. All of the efforts of the members are, therefore, under the supervision of a trained leader and practical teacher.

Two methods of financing have proved popular. The usual practice is to lend a club member the sum necessary for the purchase of his pig, the only security given the bank being the member's promissory note, bearing a nominal rate of interest. The note is paid when the pig is sold or, in case of a sow-and-litter project, when the weaned pigs are marketed.

The second method is known as the "endless-chain contract." Under this plan the bank distributes a number of weanling gilts among the club members, with the understanding that these members return to the bank two weanling gilts

Photograph from Department of Agriculture

THESE LITTLE PIGS WILL GO TO MARKET

But before that event this ruddy-cheeked youngster will have enjoyed the work of feeding, fattening, and keeping a record of the gain in weight and the cost per pound of the seven porkers, which will afford him as much pleasure and pride as could any other farm pets—and decidedly more profit in the end.

from the first litter. These gilts are in turn "farmed out" to other club members on similar terms, and the bank's holding of pigs thus increases by arithmetical progression; hence the term "endless chain."

REMARKABLE ENTHUSIASM EVINCED BY PIG-CLUB BOYS

It is not surprising that bankers find their pig-club loans conducive to the establishment of cordial relations with the future farmers and swine breeders of their communities, for the interest taken in their pigs by club members is one of the most significant phases of the movement.

This interest is reflected in thousands of letters received by instructors, club agents, Department of Agriculture officials, and the bankers themselves. There was the case of a crippled child in Mississippi last summer who became so engrossed with the project of fattening his pig that he induced his parents to allow him to move his cot to a shed near his pig-house in order that he might feed his pet at midnight. One night the pig failed to eat his usual meal with the customary piggish relish; whereupon the youthful owner hobbled to the house on his crutches and telephoned to the county pig-club agent in the adjoining town and insisted upon his coming at once to ascertain the cause for the loss of appetite.

That pigs make attractive pets and are regarded with genuine affection by their youthful masters is a fact of common knowledge to all who have followed the pig-club movement. At one of the fairs in a Southern State, when a pig had been awarded a blue ribbon the boy who had raised the animal from a weanling, oblivious of the crowd, broke into the ring, threw his arms around his pet and

Photograph by George E. Hall

"WE ARE ALL IN STYLE IN THE OZARKS; EVEN THE HOGS WEAR STANDING COLLARS"

A type of wooden yoke used in Oklahoma and Arkansas to prevent pigs from rooting their way under rail fences into pastures not intended for them. This kind of protection is not needed where the pig is well cared for and provided with an ample fattening ration.

kissed it, to the delight of judges and spectators.

BOY OF SIX RAISES A CHAMPION PIG

One of the instances to which pig-club advocates refer with special pride is the experience of Jack Starr, of Midland, Texas, who wanted to join a pig club, but learned that he was too young for membership, being only six years old. Not discouraged, however, he decided to follow pig-club rules until such time as he could join. He purchased a pure-bred pig, the runt of the litter. When the pig was 10 weeks old it weighed 29 pounds. The pet was thereafter fed, according to the pig-club agent's instructions, on a properly balanced grain ration, and was allowed to graze on Johnson grass, weeds, and volunteer oats for green feed.

Jack watched carefully for the appearance of vermin, and the few lice on his pet were easily removed with an application of grease and kerosene. A mineral mixture of charcoal, wood ashes, salt, and copperas was always kept in the pen.

When the time came for Jack to exhibit his pet at the county fair it was eleven months old and weighed 450 pounds. Not being eligible in the pig-club class, the youthful exhibitor entered his pet in five other classes, taking five blue ribbons and winning $25 in cash, with which he started his first bank account. In the following November this prize animal had a litter of nine pigs, five of which were sold for $12.50 each, and the youthful breeder is now well launched on his announced career as a stock farmer.

One of the duties of each pig-club member is to write the story of his experience at the end of the season. The narrative is usually told in simple phraseology, reflecting the earnestness of the member and his keen interest in all that pertains to his pig.

Photograph from O. H. Benson

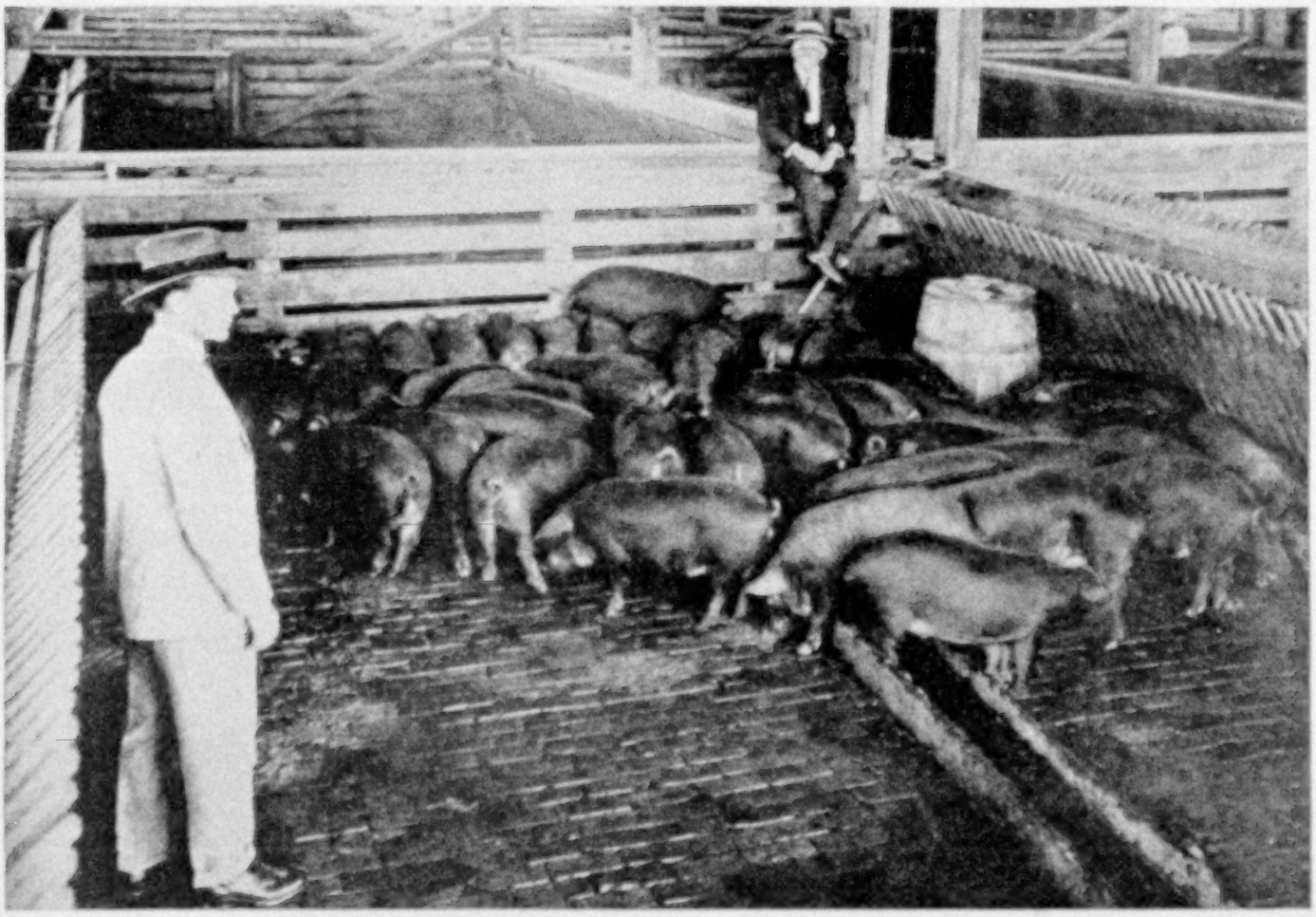
POINTING OUT TO A PIG-CLUB MEMBER THE SCORING POSSIBILITIES OF A PROMISING LITTER

To prevent canker sore mouth, pig-club members are admonished to keep the pens clean and well bedded with fresh straw. The day after the pigs are born the little tusks on the sides of the mouth should be clipped off even with the gums, a pair of bone forceps being used for the operation. The tusks should not be pulled out, however.

THE LIFE STORY OF A PIG-CLUB PIG

Perhaps no clearer or more concise statement of the cycle of a pig's existence is to be found than in the following report made by an Indiana high school pig-club member:

"The reason that I entered the pig contest was an argument that I had with a neighbor. He said that a hog would not gain over a pound a day for any length of time. I said that he was wrong and that I would prove it to him. I immediately started to look around for a pig. Because of previous observations I had made, I decided to get a Duroc Jersey. I sent to different experiment stations for bulletins relating to hogs and read all I could about them in books and farm



FIFTY-TWO PURE-BRED DUROC JERSEY PIGS PURCHASED BY A BANK AND READY FOR DISTRIBUTION AMONG PIG-CLUB MEMBERS

Few investments have proved safer than the money spent in farming communities by banks willing to finance boys and girls eager to join the pig-club movement. In some cases the necessary capital is loaned to the boys and girls on promissory notes; in others the bank purchases the pigs and farms them out, each member agreeing to return to the bank two gilts from the first litter of bred sows (see page 174).

papers. From the analyses of feeding stuff in the bulletins, I got the addresses of the firms that sold the best feed and sent for some. I went into the contest with all my heart, because I felt that I must defend my argument.

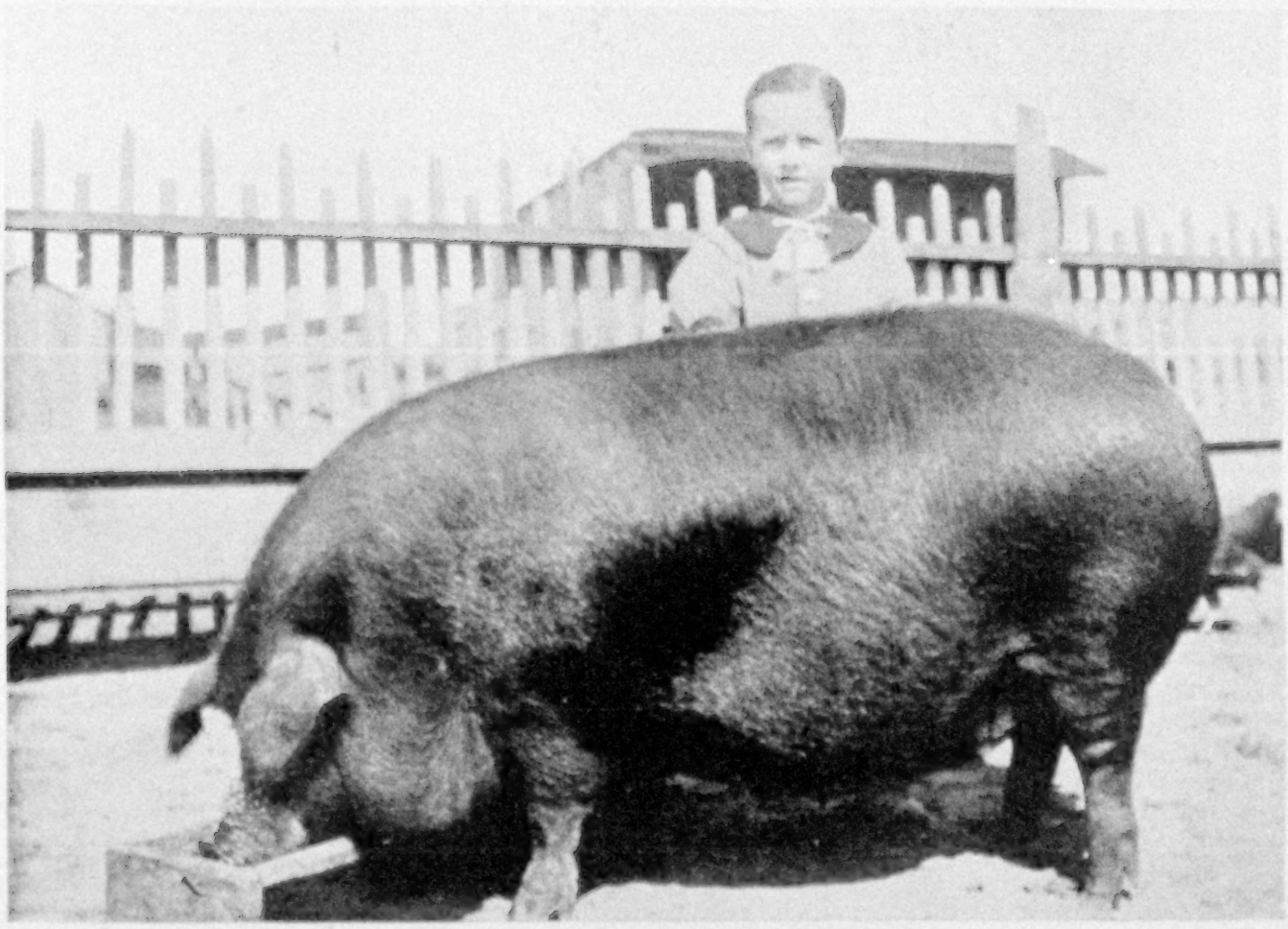
"When I got the premises I built a pig house and pen. The house was in a cool, shady place, where the sun could shine on it a few hours in the morning. Close by it I made a cement wallow and an oiler. The fence was built around the patch of rape, oats, and clover that I had sown for the pig. I made things sanitary and kept them so during the contest.

"The next step was to introduce the little red runt to his new quarters. If he was disgusted he did not show it by grunting, for after the first day he never grunted, squealed, nor rooted.

"Several things indicated that this pig needed spice for his system, and as 'variety is the spice of life,' I decided on a variety of feeds and ways of feeding which were none the worse for the pig. People must have their foods prepared differently at different meals, and as a pig comes close to being the same as some so-called humans, I prepared his feed accordingly.

"I fed only the amount of feed that the pig would clean up in a short time; consequently he ate large quantities of the pasture. I was always on the job and the pig responded, and it was not long before I had not a pig but a hog.

"The results of the contest were: the pig weighed 58 pounds at the beginning and 243 pounds at the end. He gained 185 pounds in 92 days, or two pounds a day. The cost of production was 5.03 cents a pound and the cost of the feed



JACK STARR, OF MIDLAND, TEXAS, AND HIS PRIZE-WINNING DUROC JERSEY PIG

When this pig was 10 weeks old and was turned over to Jack, as his pet, it weighed 29 pounds. Less than nine months later it weighed 450 pounds and had won five blue ribbons and $25 in cash for its youthful master.

was $9.30. The value at the end was $46.17 and the profit was $28.87.

THE CHEAP COST OF PRODUCTION

"On account of the hot weather, I kept him a few days after the contest ended, and when I butchered him he weighed 267 pounds on foot and 227½ pounds dressed. He dressed out 85 per cent. I received 25 cents a pound, which made me a total of $56.87.

"After the contest was over I wanted to see how my results compared with some other experiments, and this was what I found: Carlyle, of Wisconsin University, found that one acre of rape equals 2,436 pounds of corn meal and wheat shorts when fed in combination with these feeds. Taking one-sixth of this, although my patch was larger, it would make 406 pounds of concentrates that my pig could have eaten from the rape, not considering the oats and clover. I fed 217 pounds of concentrates and 500 pounds of milk, which is equal to 100 pounds of concentrates. Adding the three, I found that the pig could have eaten the equivalent of 723 pounds of concentrates. The Alabama Station reports that rape makes a saving of 200 pounds of grain for every hundred pounds gain. This compared favorably with my results.

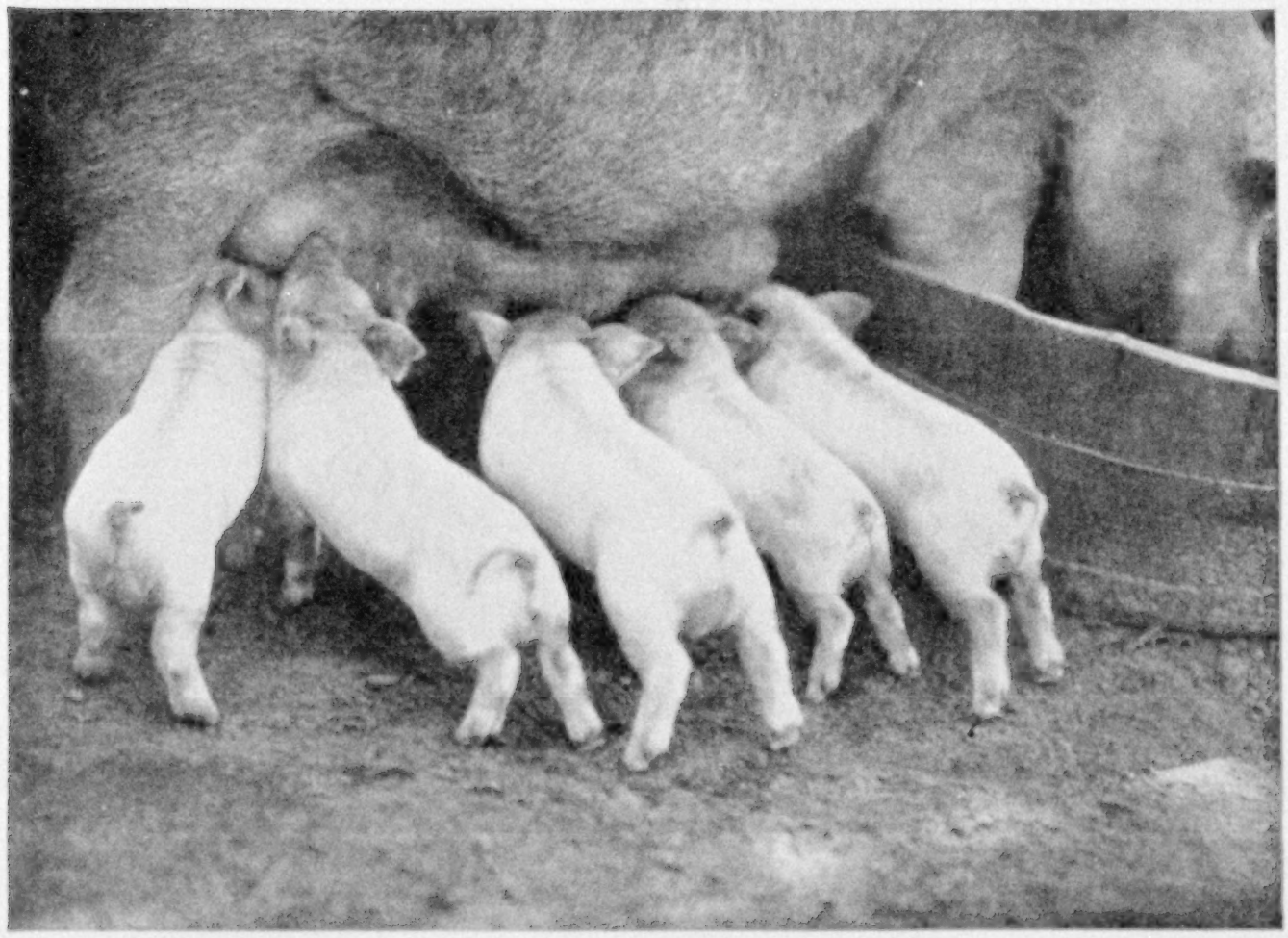
"I figured that the cheap cost of production was due to three things: First, the high protein content of the concentrates; second, good health of the pig, due to great variety of feed and sanitary condition of the lot and sleeping quarters; third, the pig consumed a large amount of rape, due to good health and appetite, thus reducing the amount of other feeds.

"Another thing that I learned was that if a boy wants something decidedly interesting he should by all means get a pig and get into the game. When the contest is over he will say that he has learned

Photograph from E. Niebergall

A HAPPY BUT EVER HUNGRY FAMILY

With the dawn of their earthly existence all healthy pigs demonstrate that they have inherited that most typical of piggish characteristics, an insatiable appetite, which enables them to gain from one to two pounds in weight a day, after they are a few weeks old



Photograph from E. Niebergall

THEIR FULL DINNER-PAIL

Pigs are usually weaned when they are from 10 to 16 weeks old. Those weaned before six weeks of age usually have dairy products to rely on. The only advantage of early weaning is to enable the sow to raise two litters a year.

something that he never knew before and probably will never forget, because he learned it by experience."

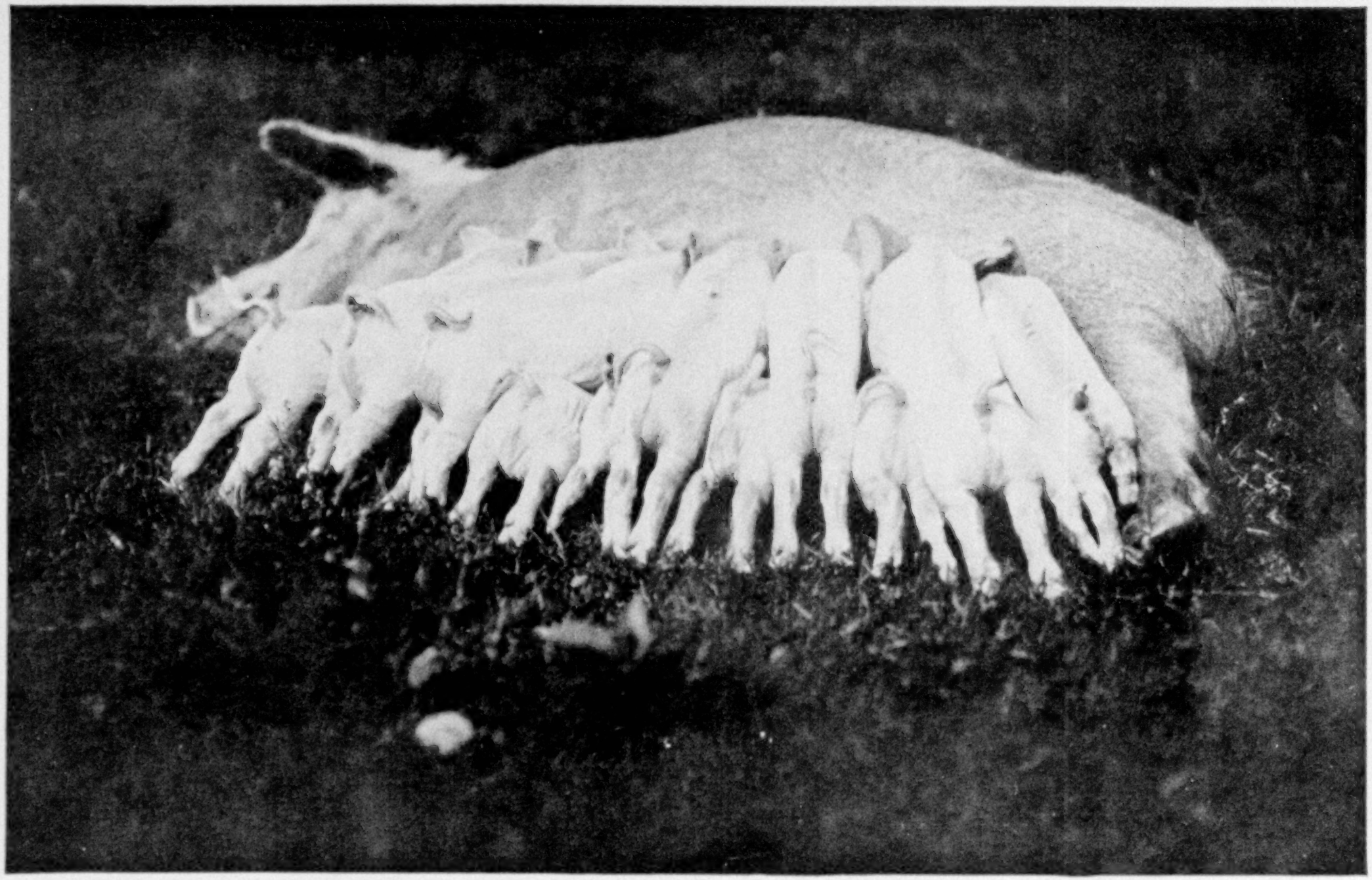
PIGS RIVAL DOGS AND CATS AS PETS

Many of the pig-club members write of their pigs with the same affectionate interest that other children speak of a pet dog, a cat, or a canary. Here, for example, is an extract from a letter by Earl West, of Garland, Oklahoma:

"Well, I shall tell you about my pig. It is looking pretty dressy since I have been feeding it digester tankage. It looks like it were fixing up for a trip. It carries its tail curled and walks as proud as if it were expecting to see town. Now I shall not disappoint him. I shall carry him to our contest on the 18th. I tell him to eat all I give him and I will do my best to get a ride on the train for him.

"He carries his fat nicely and walks up to his meals like a little boy and eats all he can. I feed him corn, oats and tame weeds, and the wastage from my father's table since my digester tankage gave out. He seems to think it is good. The funniest thing is to see him eat and look at me and grunt as if to say, 'Early, you are so good to me—everything furnished. All I have to do is to walk up and eat.'

"Now if he wins no prize I shall never be sorry about feeding him, for he shall help be a comfort for my mother and little brother at home. Besides, I enjoy his being here. While I am a member of the pig club, I tell him he must not let me get beat, for this is my first effort to do anything in the club work. But if I do get beat I shall only keep trying. My two older brothers won valuable prizes last year in the corn and cotton clubs. I shall keep trying. I am sure I can win something some day. I have one acre in corn this year, one acre in kafir-corn, and am preparing my exhibits, also my seed



Photograph from E. Niebergall

A DOUBLE-DECKER

Among farm animals the pig ranks second as a producer of human food from a given amount of digestible matter consumed. The milch cow ranks first. After the pig come poultry, steers, and sheep, in their power to convert crops of the field into food for man.

kafir-corn and corn for another year, and shall send in my report and essay when the time comes.

"The chinch-bugs got in my kafir-corn, and the drought came on my corn, but mother says I must be patient. She says that those that have no misfortune die of young age. I have always found my mother true, and I shall be patient until I get through. I am 10 years old and can always find work to do."

TEACHING THE FARMER THROUGH HIS SON

The results which have attended the efforts of food-production specialists in club work among the young people have been in marked contrast to the comparatively slow process of inducing the adult farmer to adopt modern scientific methods in raising cereals, cattle, poultry, swine, and vegetables.

One explanation for this success is the fact that boys and girls assimilate new ideas more readily than their elders. Indeed, agriculture experts are finding that the easiest method of approach to the adult farmer and the housewife is through the sons and daughters, whose signal achievements in club work furnish concrete examples of the advantages to be derived from scientific farming and the scientific breeding of cattle, swine, sheep, and horses.

For example, no number of pamphlets or lectures could be so convincing to the Decatur County, Georgia, farmer with respect to the advantages of scientific pig feeding as was the object-lesson furnished by his little daughter, who begged to be allowed to join the Decatur County Pig Club with the eighth pig of a litter. She was given the pig because the sow could only nourish seven pigs and the eighth otherwise would have starved. When the child's pig was 10 months old it weighed 225 pounds net, dressed as meat, besides yielding a 50-pound can of lard. This pig had been raised at a cost of five bushels of corn and the kitchen garbage. The other seven pigs of the litter, left to shift for themselves, averaged only 87 pounds each when butchered.

And what farm expert could have presented the story of scientific hog-raising so forcefully to a Kentuckian as the triumph of that farmer's own pig-club son when both started even with litter-mate pigs purchased at eight weeks old? The records show that the boy's pig weighed 27 pounds when purchased, and gained 167 pounds in four months, at a cost of five cents a pound—a daily gain of one and two-fifths pounds on a ration of corn, shorts, and buttermilk. At the fair the boy's sow weighed 194 pounds and took a prize; the father's weighed only 50 pounds, and there was no record of what it had cost him.

MANY BENEFITS FROM BOYS' AND GIRLS' CLUBS

The benefits derived from the pig-club movement—and similar benefits are derived from all the other club movements of the so-called Extension work of the various States, in coöperation with the U. S. Department of Agriculture—are manifold. First and foremost, the clubs stimulate an interest in swine production and teach the boys (the farmers of the future) how to raise better and cheaper hogs by the use of improved blood and the growing of forage crops. The number of hogs raised on the farm is increased and the meat required for home consumption is produced instead of bought.

The pig club is complementary to the work of the corn club, showing the members how they can market their corn profitably through hogs. The home curing of meat is encouraged on the farm. The boys are instructed in a practical way in the management, feeding, sanitation, and prevention of disease of swine.

One of the chief advantages which is being derived from this movement is the means which it affords boys and girls of earning money for themselves while at home, and at the same time awakening a real and abiding interest in farm life—a powerful back-to-the-farm movement inaugurated at the very source.

While emphasis has been laid here upon the pig clubs, the canning clubs, poultry clubs, baby-beef clubs, potato clubs, corn clubs, and sheep clubs are no less vital to the welfare of the nation and to the increase of our agricultural re-

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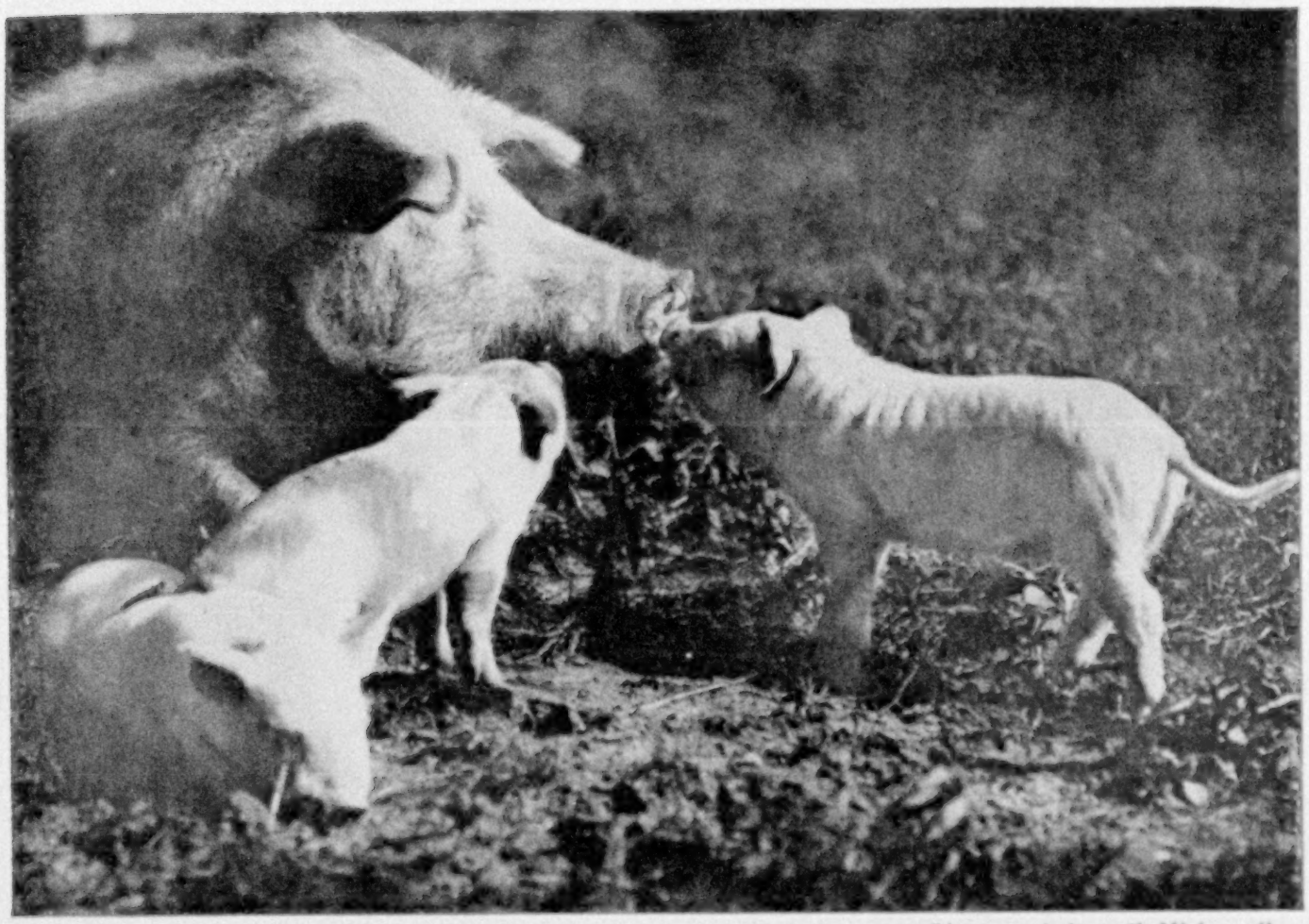
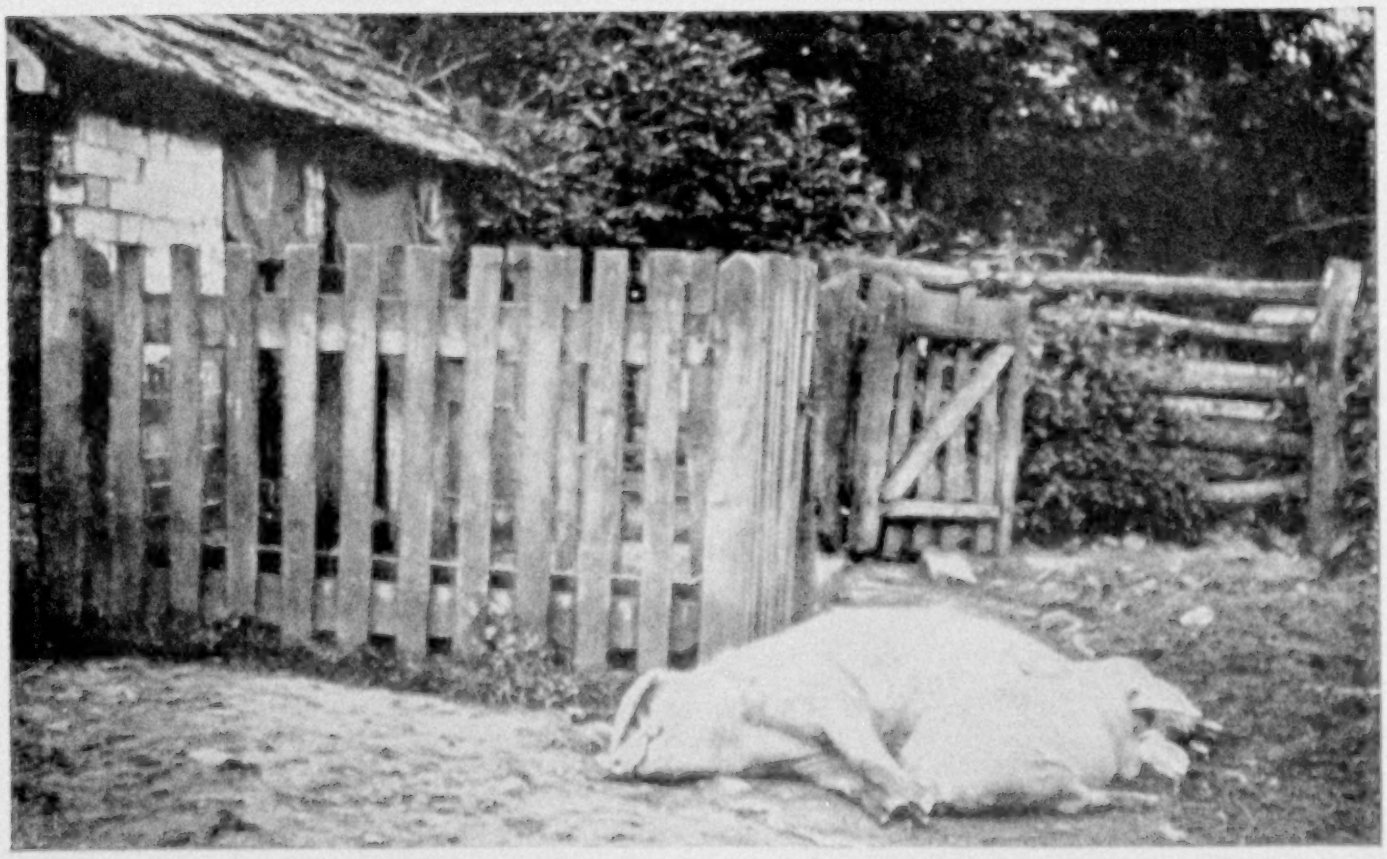


Photograph from E. Niebergall

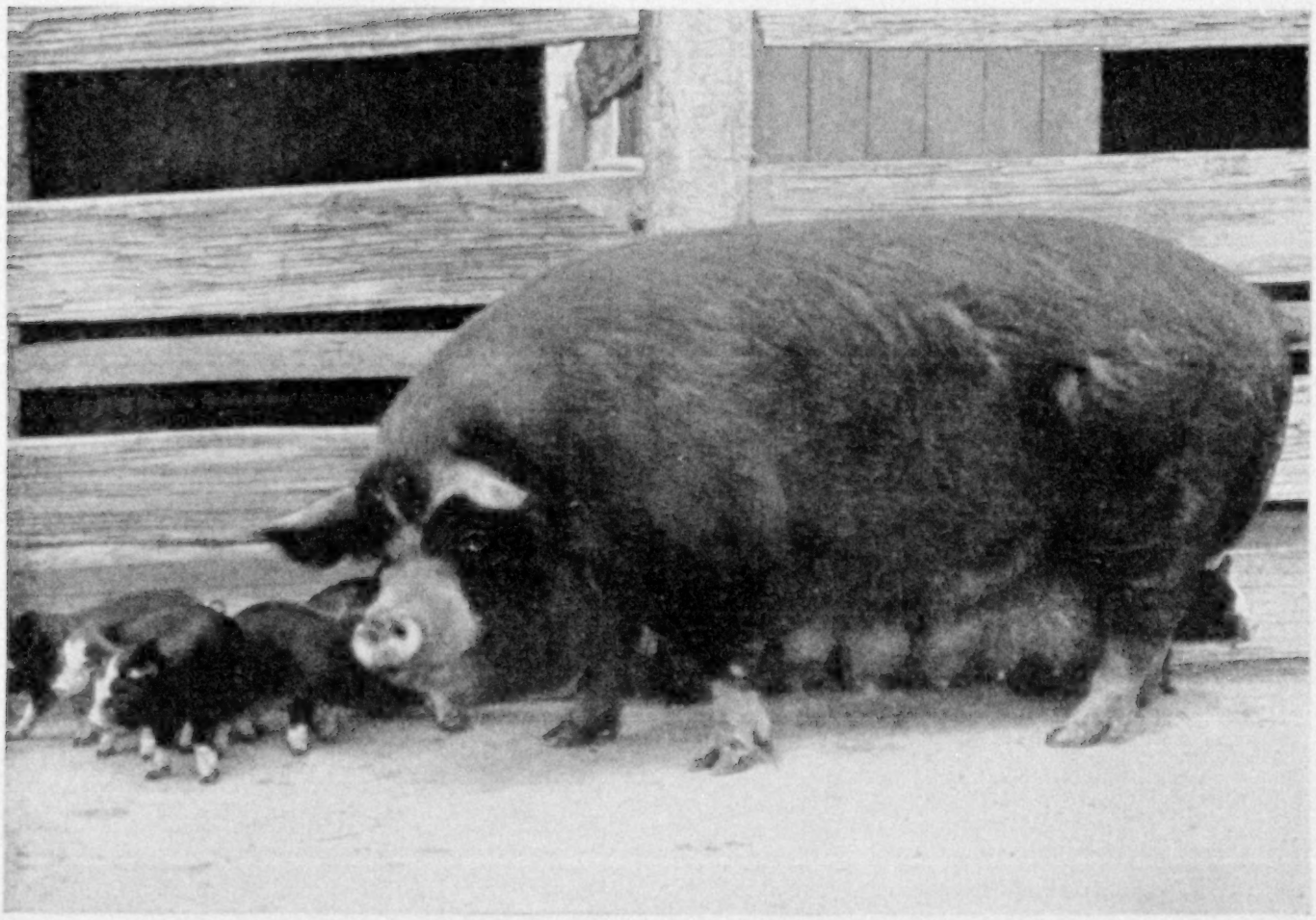
A PIG'S KISS



Photograph by A. W. Cutler

PRACTICING THE SECOND PRINCIPLE IN THE PIG'S SCHEDULE OF LIFE—EAT, SLEEP, AND GROW FAT

When the pigs are asleep the chicks become bold, a revised version of "When the cat's away." The biddy at the right is trying to make up its mind whether it is safe to approach any nearer and peck the insect which the owner of the pigs overlooked when the bristles were treated with lard and kerosene to remove vermin.



Photograph from Janet M. Cummings

A FAMILY OF WHICH ANY CLUB MEMBER WOULD BE PROUD TO CLAIM OWNERSHIP

But this is not an American sty-hold. This sow is rearing her litter in Australia, one of the great meat reservoirs of the world.

sources. They are interdependent and mutually stimulating. It frequently happens that one active boy or girl is a member of several clubs, doing equally efficient work in all. In other cases different members of the same family belong to different clubs and there is wholesome rivalry as to which will realize the greatest profit and capture most prizes in his or her particular field of activity.

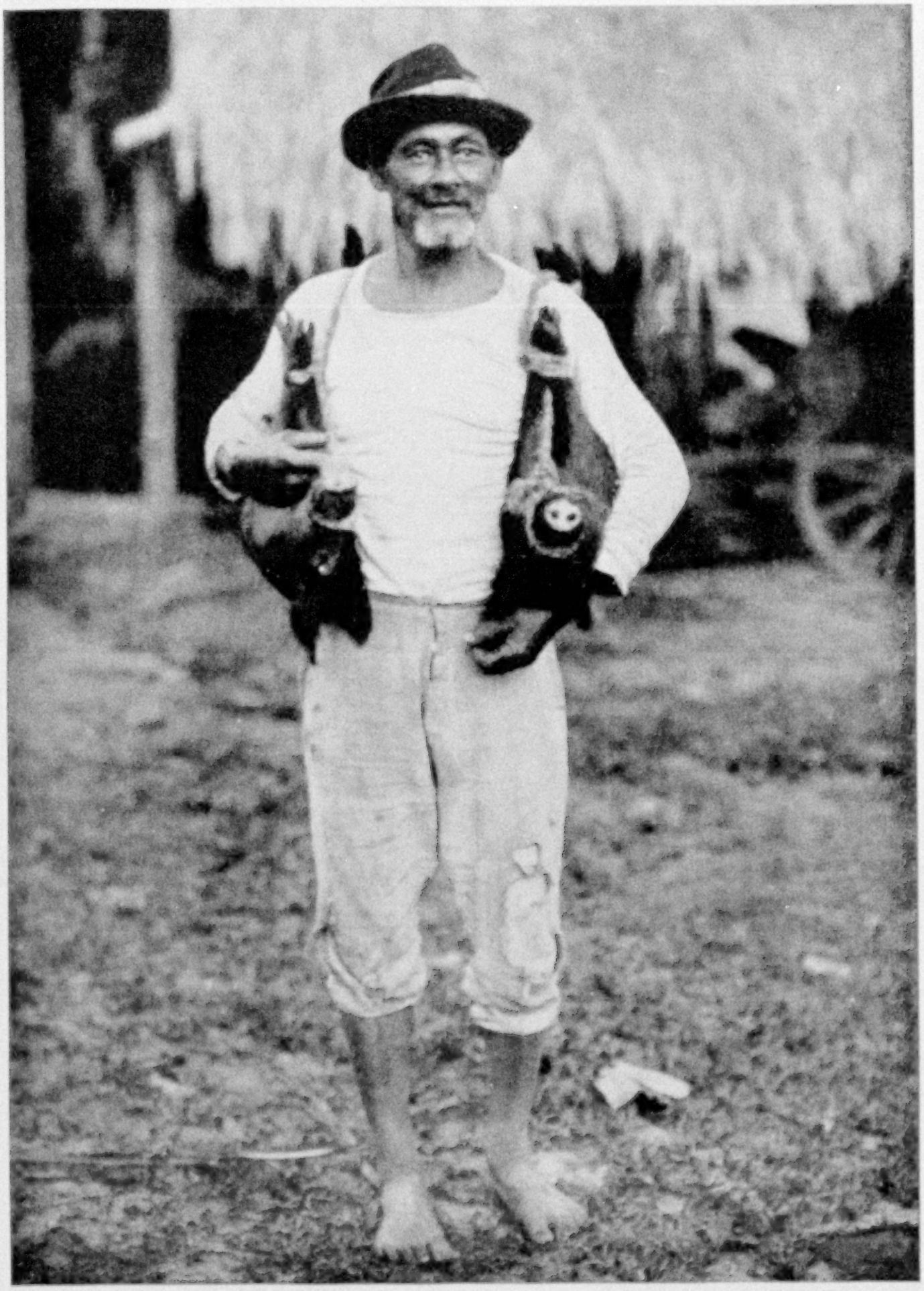
THREE PRIZE-WINNERS IN ONE FAMILY

A notable instance of family coöperation is to be seen in the achievements of the three White boys of Norwood, Madison County, Tenn. Each sent into the county club agent his record book illustrated with excellent kodak pictures, and each picture was adorned with a small American flag in the corner, indicative of the patriotic spirit of these young soldiers of the commissary.

Bronson White raised 120 bushels of corn on his club acre, and after deducting $20.35 for expenses (including $5 for rental of the land) he had a profit of $129.66. He also won a $10 prize in the boys' corn club contest, and with this money purchased from his older brother a registered Poland China pig, which he "thinks will make a prize-winner."

Robert White produced 140 bushels of corn on his acre, which was sold for $175, giving him a net profit of $153.88. With a part of this money and $32 which he won in prizes he purchased half interest in a small flock of sheep, and in connection with this investment he adds the following postscript to the history of his corn-club activities:

"The sheep is one of the most money-making animals you can raise on the farm. Boys, just think about 18 pounds of wool off one ewe at 75 cents a pound and $50 for her twin lambs at five months old—$63.50 for wool and lambs. Then I took her to the fair at Jackson and won $6 over Obion County's best sheep breed-



Photograph by A. Moscioni, from Lt. Adolfo de Hostos

PACKING PIGS TO MARKET IN PORTO RICO

A comparatively comfortable method of transportation for both man and beast; but if this native Porto Rican had practiced pig-club methods, he would have so much pork on his shoulders that he would scarcely be able to stagger under the load.

Photograph by Emil P. Albrecht

"A CORNER IN PIGS": MARKET DAY IN ST. BRIEUC, FRANCE

Scrubbed till its skin glows pink through glistening white bristles, the St. Brieuc pig, in its rope harness, is a thing to admire, no less than the many different types of headdress worn by these thrifty Breton women. Each type of cap bespeaks the village from which the wearer and her pig hail.

ers. Now, adding that to the other, she netted me $69.50 profit, and I still have the ewe!

"Yet I have heard farmers say that they did not like sheep. But, boys, give me rich land to work, warm clothes to wear, and a stomach full of barbecued lamb, and Bob White does not mind putting his shoulder to the wheel."

A BOY'S PLEA FOR MORE HOGS

The third and oldest brother, J. B., raised 145 bushels of corn on his acre, the net profit on which was $159.90.

With the profits from his previous corn-club crop, J. B. purchased 20 pigs, which then weighed 33 pounds each, but which at the time of his report averaged 402 pounds. He enclosed with his report a picture of three of his porkers, "Billy Sunday," "Mattie L.," and "Tennessee Bell," and of these he writes:

"Billy Sunday won first prize under one year in the Poland China ring. Mattie L. did the same thing in her class. Tennessee Bell, the little Hampshire pig I won in the boys' corn club last year, weighed 33 pounds. I brought her home in a cracker box. This year she won first prize under one year in the Hampshire ring, and also champion over all breeds and ages.

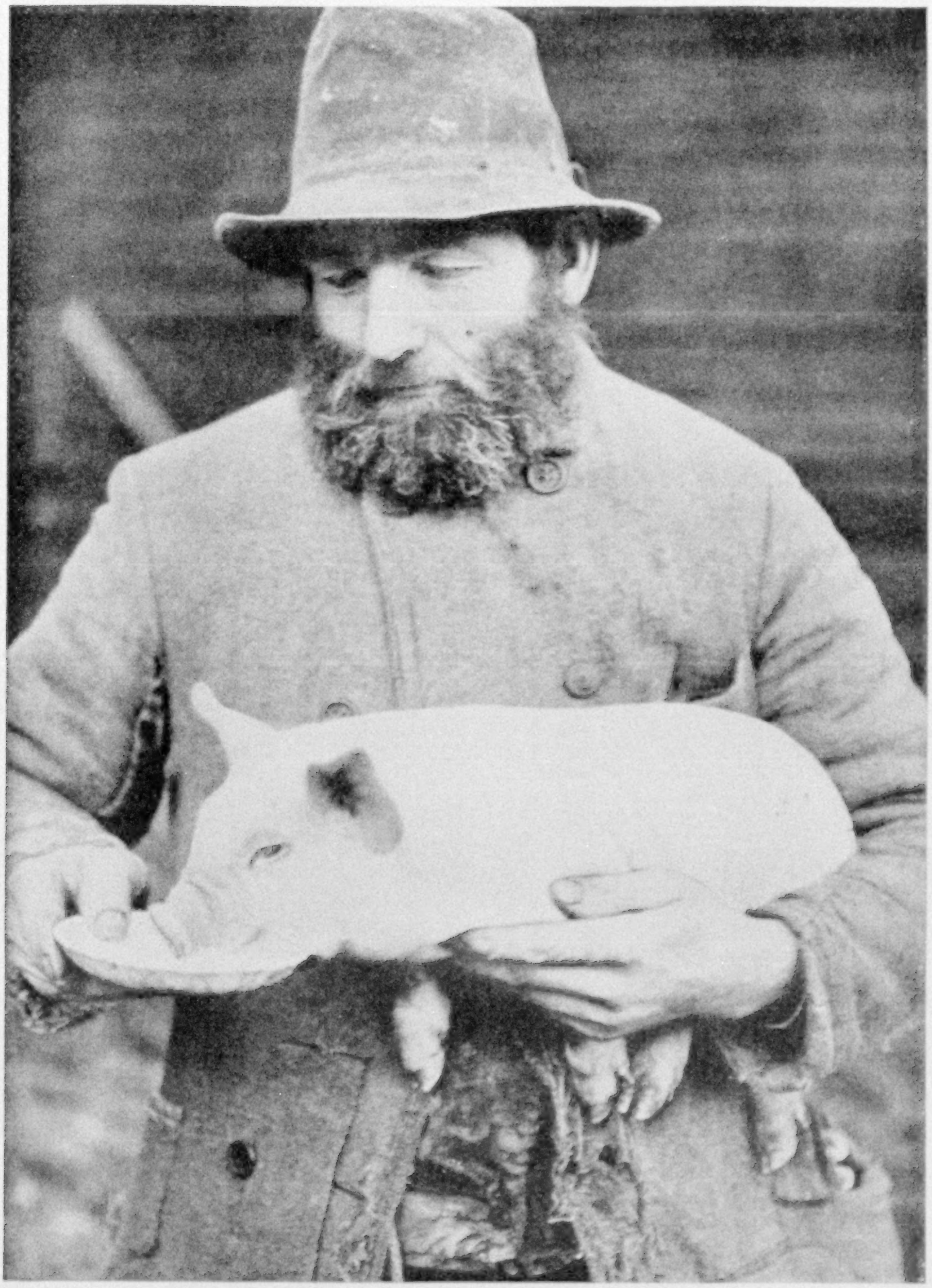
"These pigs were raised on crimson clover, alfalfa, and soy-beans, with very little corn—about one ear a day. They are now running on a field of soy-beans and peas without any corn.

"Boys, we ought to raise more hogs and especially brood sows to produce an early fall litter. We can do it if we will provide good grazing, so that they can get a large part of their food. The forage crops should be grown to save the corn, so that we can raise the pigs much cheaper.

Photograph by G. Heurlin

"SPEAK FOR IT"

Many of the pig-club boys and girls manifest the keenest affection for their pork-producing pets, and occasionally there is a most pathetic note in some of the letters received by the pig-club agents when lightning, a train, or hog cholera kills the animal upon which time and labor have been lavished. "You can mark my name out," wrote one boy. "My pig is dead; I ain't got no money to start with again and no feed. I am in a bad fix for starting and I will have to give it up."



Photograph by G. Heurlin

PURE-BRED AND HAND-FATTENED

There are two distinct types of swine—the lard and bacon types. The lard type is much preferred in the United States, while the production of choice bacon is more general in those countries where the feed of the hog is more varied and where corn is not the principal fattening grain.

Photograph by G. Heurlin

FOUR LITTLE PIGS

Instead of being the unclean, insanitary creature almost universally depicted, the pig is much more cleanly in its habits than the dog. It makes a desirable pet for youngsters living in the suburbs as well as on the farm.

Photograph by G. W. Groff

WICKER-BOUND PIGS BEING TRUNDLED TO MARKET ON CRUDE WHEELBARROWS: CANTON, CHINA

The thrifty yellow race knows how to make the most of its meat resources. A poor pig is seldom seen in China.

"Boys, stay on the farm and come to see me after hog-killing time and I will feed you on back-bone, spare-ribs, sausage, ham, and red gravy."

In the hands of such youthful farmers the ample productivity of American soil is assured.

HOW YOUNG PATRIOTS MAY ENLIST

All young patriots who are willing to offer their services in the cause of producing more food for our own soldiers and our allies, and who at the same time wish to earn a handsome profit on their investment and experience the joy of watching growing things—pigs, sheep, corn, calves, etc.—should write either to the Agricultural College of their State or to the Department of Agriculture, Washington, D. C., stating in which club they are interested.

A State or county agent will immediately answer such inquiries and furnish accurate information as to the best meth-

Photograph by Deck Lane

ON A PENNSYLVANIA FARM: THE PET-SHEEP MOVEMENT IS FINDING FAVOR IN THE EASTERN AS WELL AS THE WESTERN STATES

A sheep can be raised as cheaply as a dog and ordinarily will produce $5 worth of wool annually. When reduced to mutton it will average $10 in value. A sheep-club boy in Tennessee reports having secured 18 pounds of wool from one ewe ($13.50), and sold her twin lambs when five months old for $50—a total of $63.50 for wool and lambs—and he still has the ewe (see page 185).

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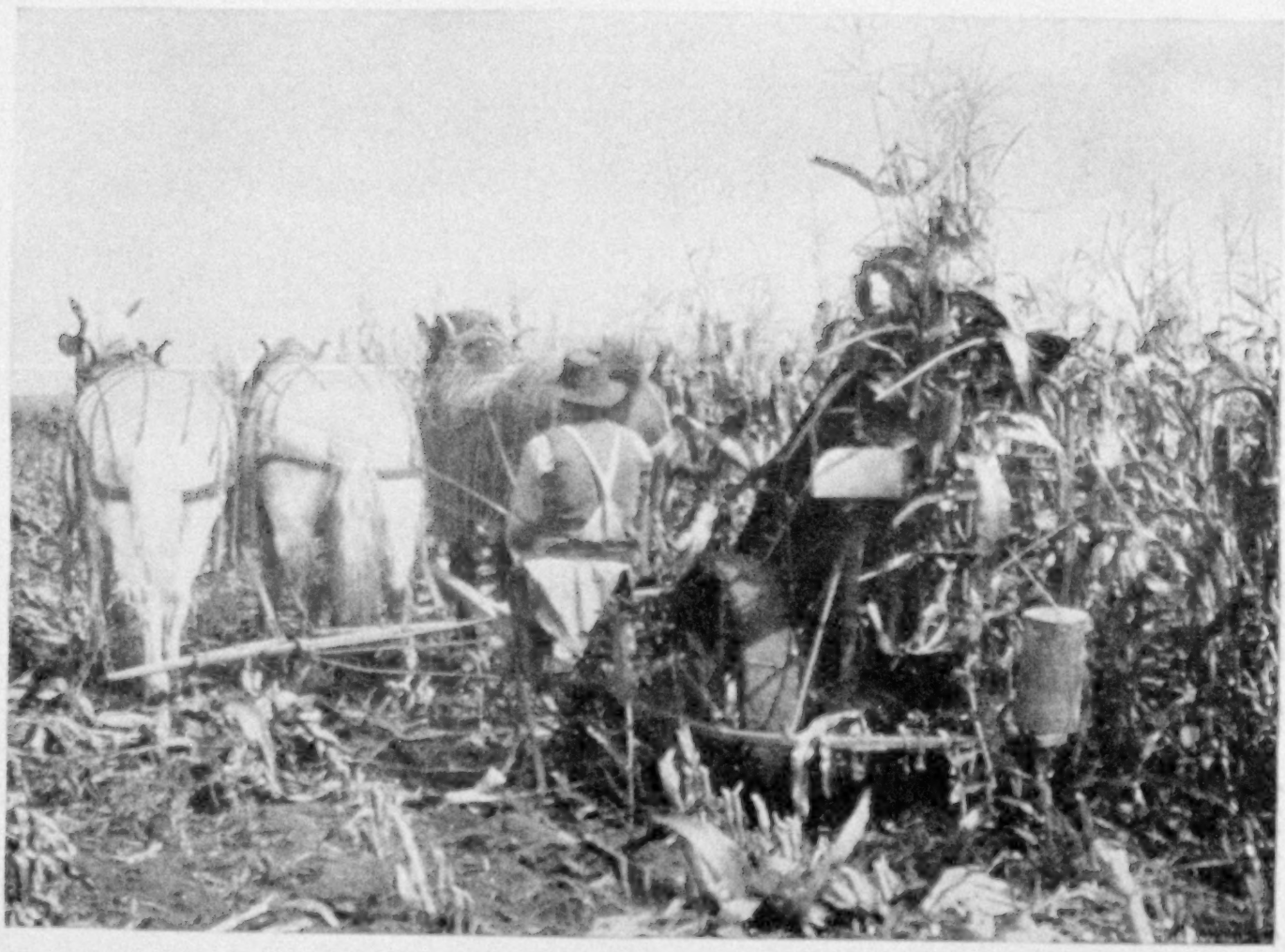
Photograph by R. R. Sallows

PICTORIAL EVIDENCE WOULD SEEM TO INDICATE THAT CANADA HAS ORGANIZED BOYS' PUMPKIN CLUBS



AMERICAN FARMERS ARE BEING TAUGHT SCIENTIFIC AGRICULTURE THROUGH THEIR SONS AND DAUGHTERS

The corn clubs and pig clubs are closely related. It was to provide a profitable method of marketing the boys' corn harvests which first suggested the idea of pig clubs to a rural school superintendent in Caddo Parish, Louisiana, eight years ago.

ods of raising pigs, of planting corn, etc. This information is supplied without charge, and the government agents will gladly give expert advice, call wherever possible to see those interested, and enroll them as club members, all without cost to the individual.

No attempt has been made in this article to set forth the methods of pig-raising or to describe the relative merits of such breeds as the Duroc Jersey, the Poland China, the Berkshire, and Hampshire. All these subjects are treated in very complete and interesting detail in the various Department of Agriculture bulletins, which are sent free, upon request.

Boys and girls living in the New England and Middle Atlantic States are especially urged to join the club movement. Their proximity to many large cities insures a constantly brisk market for farm, dairy, and meat products, and all food raised in this section of the country not only adds to the general larder of the nation, but relieves to some extent the ever-increasing transportation burden which must be borne by the government-operated railroads.

From April to November the weather is sufficiently mild in the North and East to warrant the raising of pigs in the open, without the outlay of large sums for housing equipment.

Among the Eastern States, Massachusetts has been commendably active in boys' and girls' club work. In that Commonwealth the popularity of the pet-pig movement has been second only to the interest shown in poultry clubs. New York promises to do much in this direction also, although the club work was not begun in that State until March, 1916.

Particular emphasis should be placed on the fact that a large tract of land is not requisite to the keeping of a pet pig. On a small lot in the suburbs a young porker can be fattened at negligible cost, being fed largely on kitchen waste.

BILLIONS OF BARRELS OF OIL LOCKED UP IN ROCKS

By Guy Elliott Mitchell

Of the United States Geological Survey

IS THE United States facing a gasoline famine? Shall we be required to forego automobiling except to meet the stern necessities of war and of utilitarian traffic? Are our petroleum fields showing signs of exhaustion?

The output of petroleum has not yet begun to diminish; statistics show that it is still increasing; yet the downward trend of production from the present oil fields is plainly in sight.

The war has made a sudden and enormously increasing demand on the oil fields of America, and though the industry has never been so feverishly active as it is now and the output never so large, the truth is that the demand has not been entirely met. And during the next year and as long as the war lasts the demand will be ever increasing, ever more pressing.

Many of the host of larger vessels that we are now building will be equipped with oil-burning furnaces, and the vast swarm of airplanes that we are building, as well as the thousands of war automobiles and trucks that we are turning out, will consume an enormous quantity of gasoline. Yet no great new oil regions comparable with the mid-continent or California fields are being discovered, and it is questionable whether any will be, for our oil geologists have pretty thoroughly combed the accessible oil areas. What, then, is the answer?

It is just at this juncture that we have made a discovery that has disclosed what is undoubtedly one of our greatest mineral resources—one that should supply the needs of the war, and that for generations to come will enable the United States to maintain its supremacy over the rest of the world as a producer of crude oil and gasoline and incidentally of ammonia as a highly valuable by-product. We have discovered that we possess mountain ranges of rock that will yield billions of barrels of oil.

For many years travelers going west through the Grand River Valley of Colorado and into the great Uinta Basin of eastern Utah have looked from the windows of their Pullman cars on the far-stretching miles and miles of the Book Cliff Mountains, little realizing that in these and adjoining mountains, plainly exposed to view, lay the greatest oil reservoir in the country—the oil shales of Colorado, Utah, Wyoming, and Nevada.

ROCKS THAT BURN FREELY

These shales, it is true, were known to yield oil. Campers and hunters in building fires against pieces of the rock had been surprised to find that they ignited and burned, and investigation showed that they contain oil. This fact was looked upon, however, as only another of the natural curiosities of the great West and little or no attention was paid to it because of the seemingly inexhaustible pools of crude petroleum found elsewhere under great areas.

In connection with its investigations of the undeveloped mineral resources of the country the United States Geological Survey has recently made special studies and tests of these oil rocks and has brought to light two important facts: First, that our western shales are phenomenally rich in oil, and, second, that in foreign countries, particularly Scotland, much inferior shales are today successfully mined and worked as a source of oil and other commercial products. The industry in Scotland is 70 years old and is still in a highly flourishing condition.

OIL PROFITABLY DISTILLED FROM SHALE IN SCOTLAND

The Scotch shales run only about 25 gallons of oil to the ton; yet the principal operating companies competing with the petroleum industry pay annual dividends averaging 18 per cent. Rock producing

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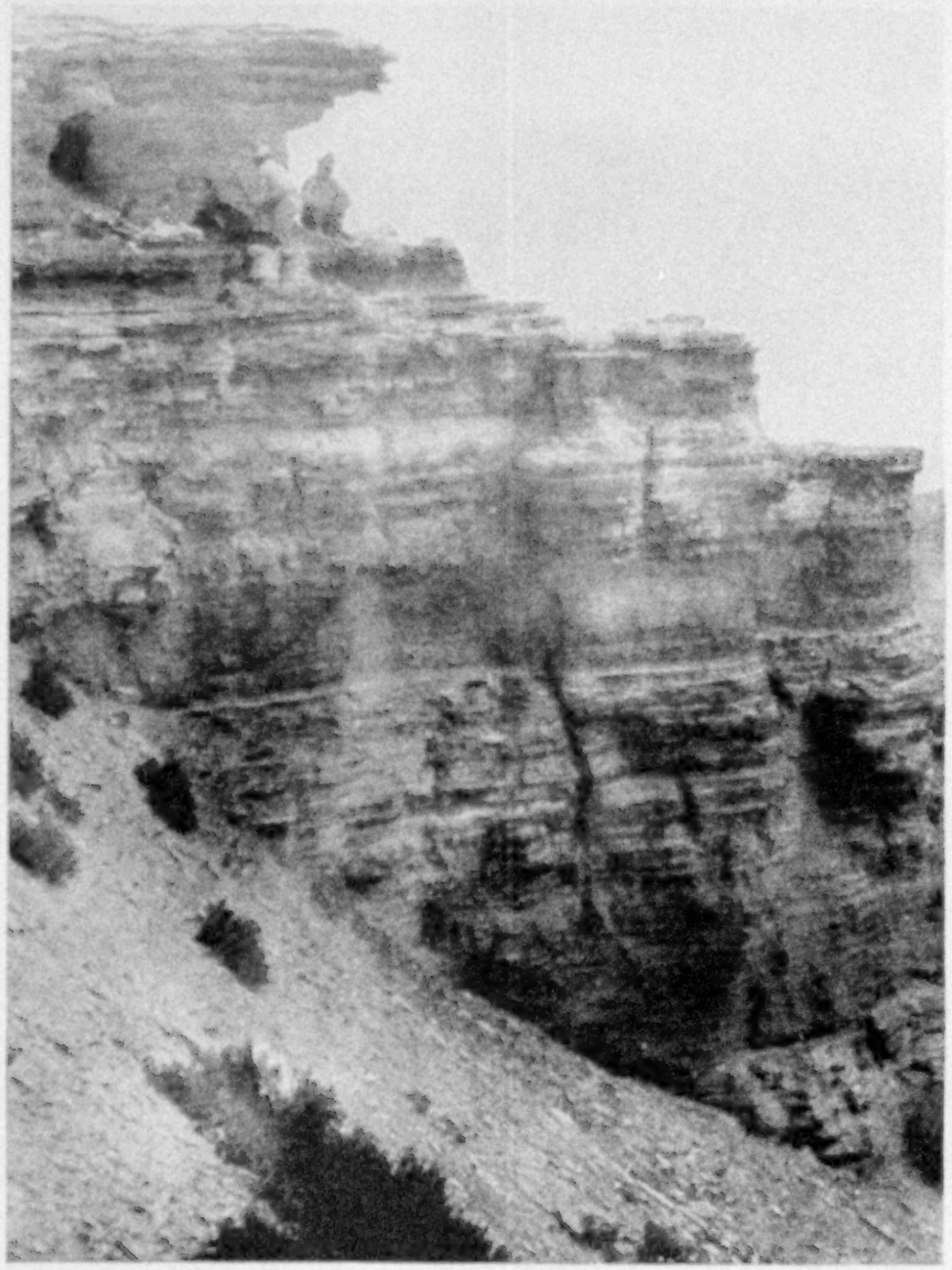
Photograph from U. S. Geological Survey

GEOLOGICAL SURVEY MEN SAMPLING ONE OF THE GREAT OIL SHALE BEDS NEAR GREEN RIVER, WYOMING

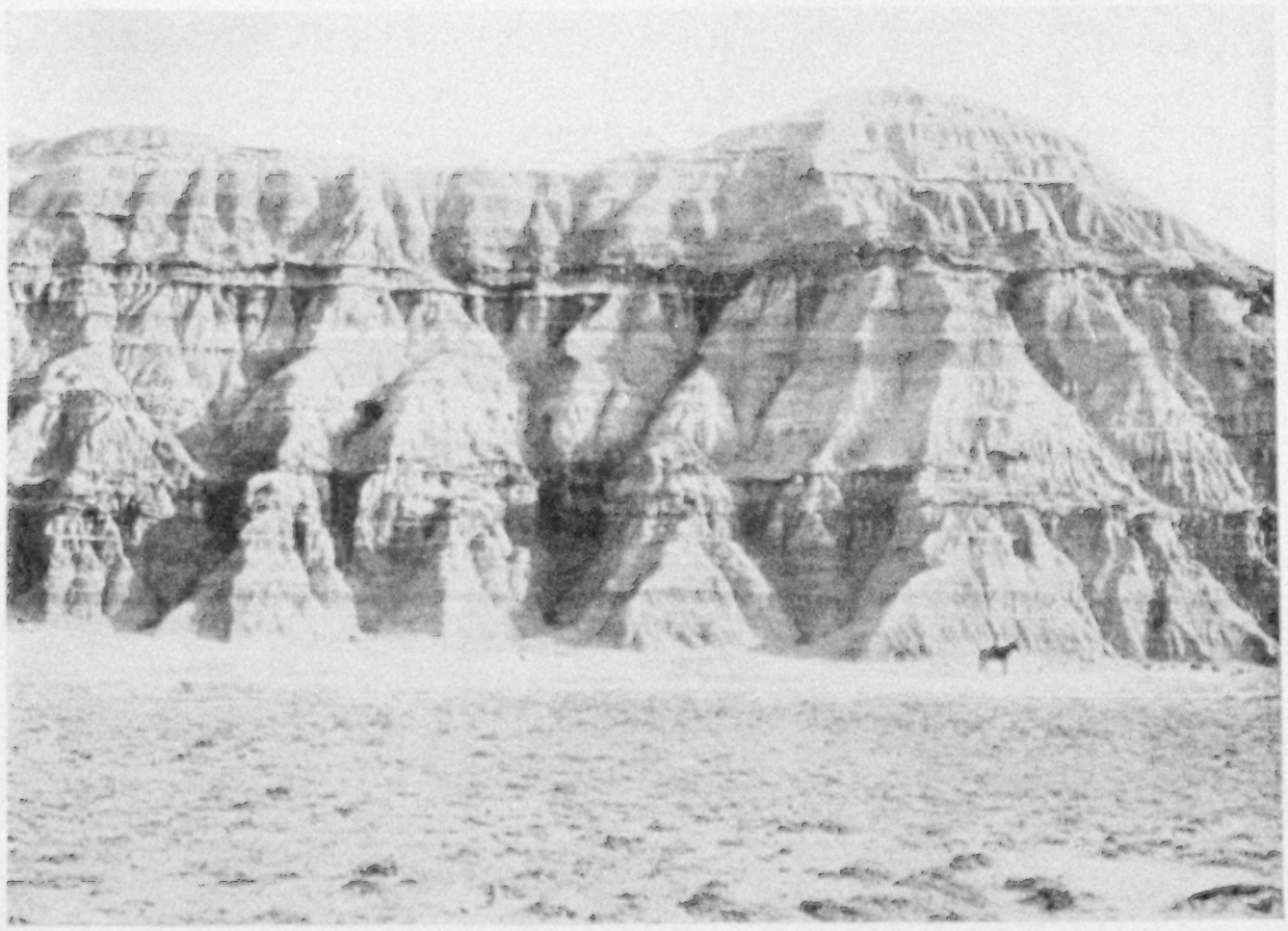
As the great Creator, through His servants of old, caused water to flow from the rock in the wilderness, so, through twentieth century science, He is causing oil, for ages locked up in the shales of America, to be released for the relief of human necessity.



Photograph from U. S. Geological Survey

GOVERNMENT GEOLOGISTS AT WORK ON AN OIL SHALE DEPOSIT NEAR WHITE RIVER, COLORADO

The results of the experiments in distilling from Colorado oil shale have been so promising that a reserve of 132,000 acres of the richest region has been set aside by the government as a source of the oil supply for the United States Navy.



Photograph from U. S. Geological Survey

IN THESE WYOMING ROCKS ARE LOCKED MILLIONS OF BARRELS OF OIL

These deposits of oily rock are often massive in extent as well as in thickness. Beds were recently reported in one Western State over an area of 1,500 square miles, averaging 20 feet in thickness and yielding at least 36 gallons to the ton.

even as low as 20 gallons of oil a ton is yielding good dividends. The shales in the western United States are far richer in oil than those of Scotland. Many tests made by the Geological Survey show that the American rocks contain 40 to 50 gallons to the ton and those in one deposit tested 90 gallons, or more than 2 barrels, to the ton.

To extract the oil, the rock is distilled at a low temperature. So simple is the process that the geologists who surveyed the fields carried small testing retorts around from place to place to determine the oil content of various specimens.

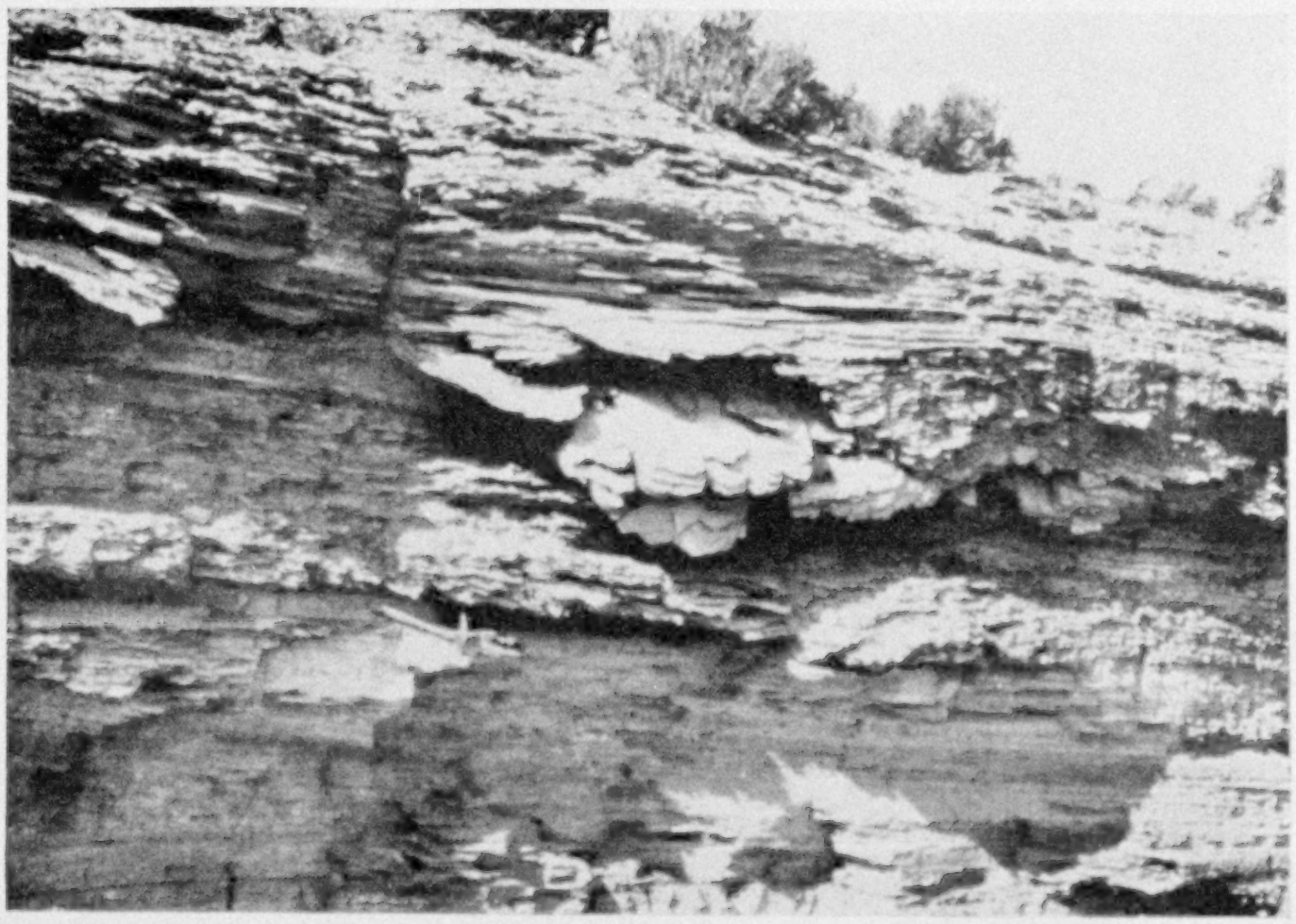
In the Scotch plants the rock is heated in retorts arranged in banks of four over a single fire-box, and a unique feature of the process is that the gas derived from the shale is the fuel used for obtaining the oil and other products. The retorts are grouped in benches of 64 and each retort reduces about 4 tons of rock a day. Some 3,000,000 tons are treated annually. The vapors pass from the retorts into condensers in which the crude oil is deposited, and then on into a chamber in which the ammonia is collected.

The Scotch shales yield gasoline, illuminating, lubricating, and other oils, paraffine wax, and sulphate of ammonia, besides a considerable quantity of liquid fuel and the gas that is used in the plants.

QUANTITY OF OIL IN AMERICAN SHALES ENORMOUS

The total production of petroleum in the United States up to 1918 has been 4,255,000,000 barrels, and the possible future production, or the total reserve in the ground—and some of it lies very deep—is estimated by the Federal Government at about 7,000,000,000 barrels.

How does this petroleum compare with the known oil-shale reserve? The quantity of oil that can be extracted from the



Photograph from U. S. Geological Survey

AN OUTCROP OF RICH OIL SHALE IN UTAH

The flexibility of the rock indicates its heavy oil content. The oil shales of Scotland, which have been profitably worked for 70 years, yield about 25 gallons to the ton of rock. The shales of the western United States run about 40 or 50 gallons to the ton and those of one deposit gave 90 gallons to the ton.

shale is so huge that the petroleum reserve becomes almost insignificant by comparison. As a result of only a partial investigation, it is estimated that the oil in the shale ranges of Colorado alone amounts to 20,000,000,000 barrels. There are mountains—indeed, ranges of mountains—which for many miles carry thick beds of rock that yield 30 to 50 barrels of oil to the ton.

More recently the State geologist of Colorado has reported that in northwestern Colorado beds of commercially workable rock that average more than 20 feet in thickness and that will yield at least 36 gallons of oil to the ton are found in an area extending over 1,500 square miles. These figures show a content of 24,000,000 barrels of oil to the square mile, or a total of 36,000,000,000 barrels for the area. Either twenty billion or thirty-six billion is sufficiently impressive.

The Geological Survey also estimates that 300,000,000 tons of sulphate of ammonia, worth, at before-the-war prices, about $60 a ton, could be recovered as a by-product in the extraction of the oil. This by-product would be sufficient to enrich most of the farms in the great Mississippi Valley.

In addition to the oil rock in Colorado, that of Utah must be considered. The government is now investigating these deposits in detail and has already stated that they are probably as extensive as those in Colorado and are equally rich in oil. Oil shales have been examined also in Nevada, Wyoming, California, Montana, and other States. Tests of specimens from Wyoming show from 30 to 50 gallons to the ton, and samples from Nevada have produced from 40 to 100 gallons of oil to the ton. One 10-foot

bed in Nevada yielded oil at the rate of 13,000,000 barrels to the square mile.

DEPOSITS IN EASTERN STATES

But the West has no monopoly of the oil-shale resource. Deposits have been examined by the government in Illinois, Kentucky, Ohio, Pennsylvania, Tennessee, West Virginia, and Indiana, some of them testing out with a high oil content. An examination of the black shale of southwestern Indiana shows that it underlies about 16,000 square miles, and although the oil content of much of it is less than that of the western shales, and some of it is too low in oil to be worked commercially, the actual content for the area in Indiana alone would be 100,000,000,000 barrels.

Some of the eastern shale that is very rich in oil overlies extensive coal beds, which are being mined by the "stripping" method, so that the oil rock must be removed in any event to get out the coal. This shale could therefore be mined by steam-shovels without additional cost, as it is a necessary preliminary to the coal-mining.

The potential value of this immense oil resource of America is almost beyond comprehension. Enough oil is held in these natural reservoirs to fill many times over every tank, cask, barrel, can, and other container of every kind in the world.

Until recently the oil shales of the United States, particularly those of the Western States, have been referred to by the government geologists as a reserve available for extraction whenever the demand and the price shall become great enough to warrant the establishment of a new industry to supplement the supply of petroleum from the oil fields. This time is now at hand.

The extraordinary demands of the war are already indicating the approaching insufficiency of the output from our petroleum fields, and experiments in the utilization of oil shale are already being made in Colorado. Plants are being erected, oil is being distilled, processes are being tested, and a steadily increasing output is soon to be expected. So substantial is this resource considered that the government has set aside as a special

Photograph from U. S. Geological Survey

HAND DRILLING TO SECURE UNWEATHERED SAMPLES OF OIL SHALE

The deposits of oil shale in the Rocky Mountain region lie for the most part near the surface and can be mined by steam-shovels. By situating the reducing plants in the valleys, gravity may be utilized in transporting the rock to the distilleries.

Photograph from U. S. Geological Survey

OLD SHALE DISTILLERY NEAR JUAB, UTAH, USED BY MORMONS A GENERATION AGO

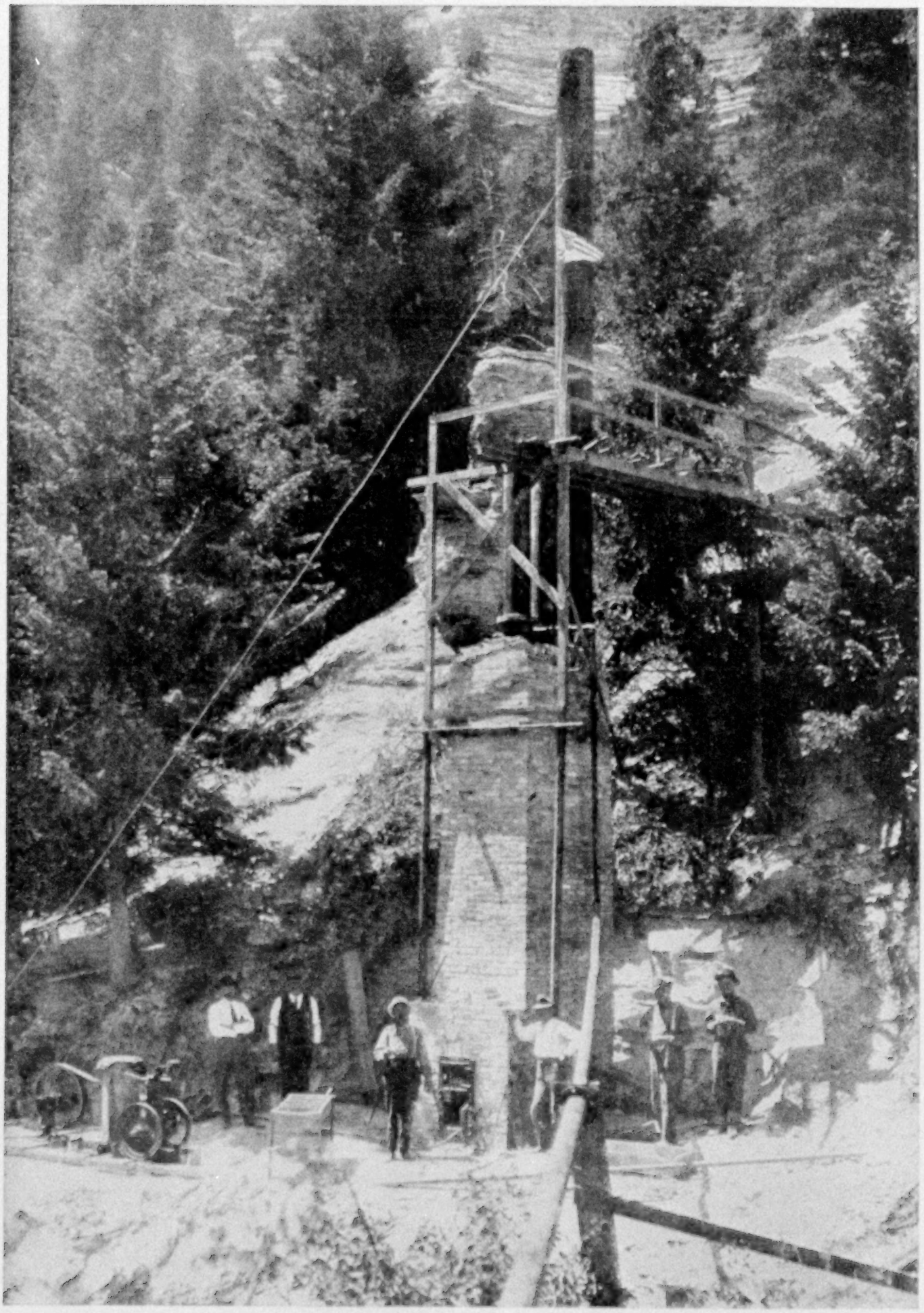
When the oil is distilled from the impregnated shales there comes with it a great supply of those yellowish crystals we call sulphate of ammonia—a fertilizer so rich that it would make a garden out of an old abandoned field. Three hundred million tons of this great soil vitalizer lie locked in the shales of Colorado alone, waiting to be released by the key of industry.

reserve for the American Navy 132,000 acres of the richest oil-shale land in the West.

BEWARE OF FAKE PROMOTERS

It is not to be understood, of course, that any farmer or rancher who may happen to have oil shale on his homestead can produce oil at a profit. Successful oil distillation will require large and expensive plants, well financed and scientifically managed, as in any other large industry.

It is by no means a poor man's proposition; but neither, on the other hand, is it a highly complex and involved industry, such, for instance, as beet-sugar manufacture, while the fact that oil dis-



Photograph from U. S. Geological Survey

NEW EXPERIMENTAL OIL STILL NEAR DEBEQUE, COLORADO

No man who owns a motor-car will fail to rejoice that the United States Geological Survey is pointing the way to supplies of gasoline which can meet any demand that even his children's children for generations to come may make of them. The horseless vehicle's threatened dethronement has been definitely averted and the uninviting prospect of a motorless age has ceased to be a ghost stalking in the vista of the future.

Photograph from U. S. Geological Survey

WASH DAY IN A U. S. GEOLOGICAL SURVEY CAMP

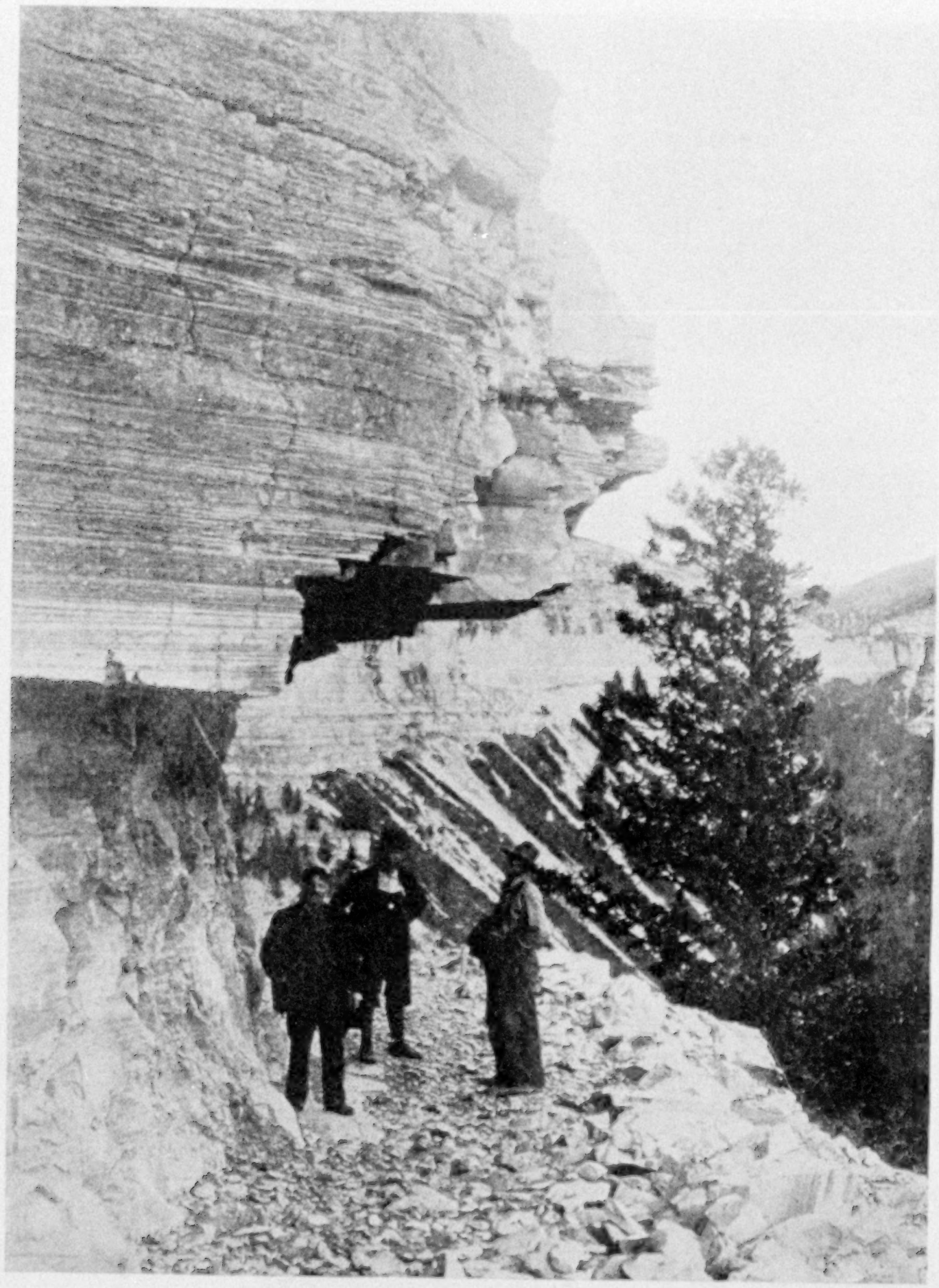
Campers and hunters in the West long ago discovered that oil shale would burn. A few rich samples are here supplying the heat for the camp laundry.

tillation is well established in other countries is tremendously to the advantage of prospective development in the United States.

Unfortunately the discovery of the immense oil resources of America, contained in its oil-shale deposits, will doubtless be attended by misfortune for the unwary—those who invest carelessly in the stock of fake or "wild-cat" oil companies, organized by get-rich-quick schemers who are intent upon exploiting the gullible public rather than the development of oil-shale properties. Such schemers, like camp-followers, appear in the wake of every great discovery of mineral wealth and they have always found the "oil fields" a particularly lucrative one for their operations.

AMERICAN OIL-SHALE INDUSTRY WILL FAR OUTSTRIP SCOTLAND

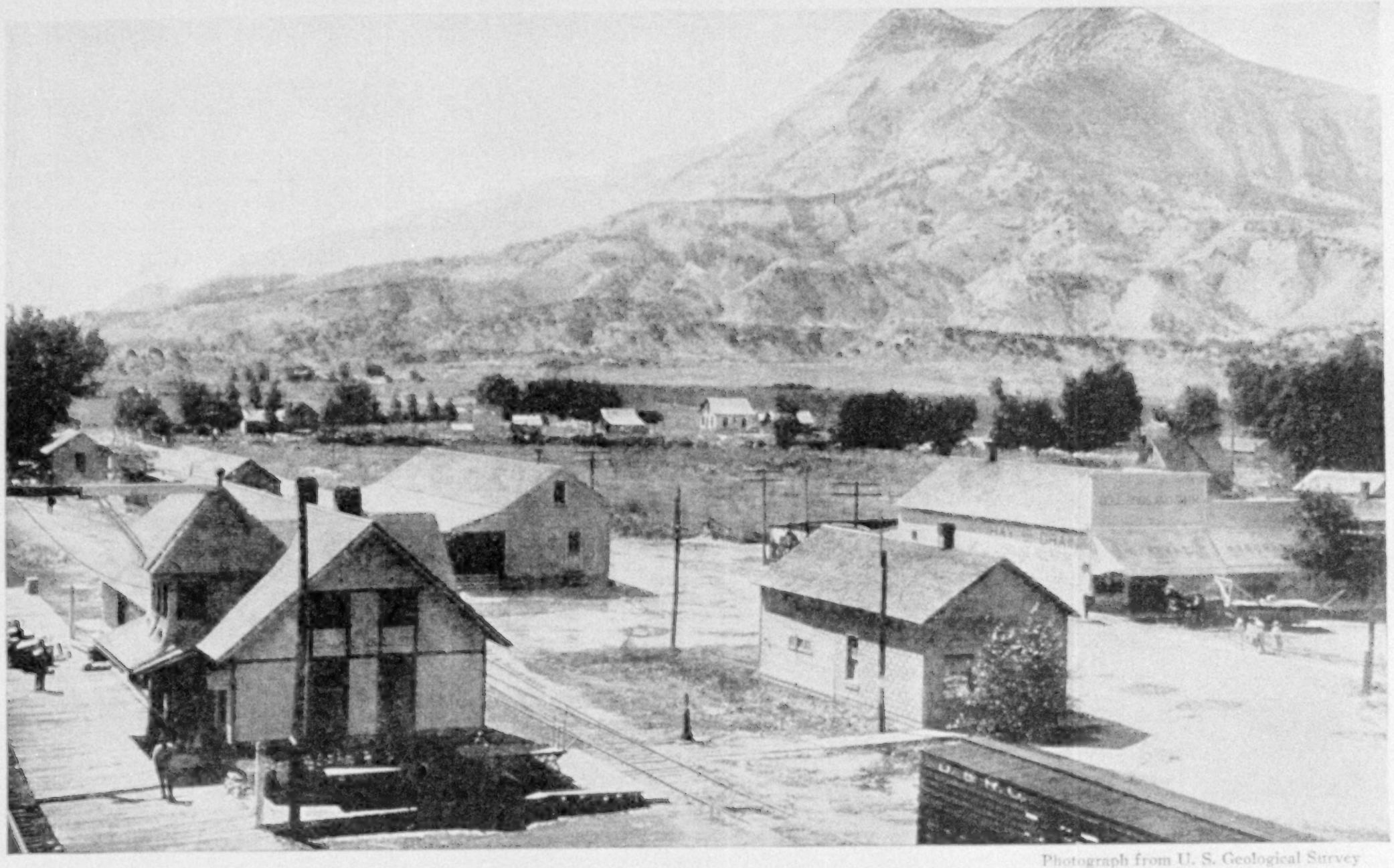
The success attained by the oil-shale industry in Scotland indicates far greater



Photograph from U. S. Geological Survey

RICH OIL SHALE LEDGE OUTCROPPING NEAR GRAND VALLEY, COLORADO

Although the oil reserves of the United States are greater than the amount produced in the entire world from the birth of the industry until now, yet the output at the present time is such that it would exhaust the reserves in 30 years. But now comes the discovery of such an abundance of oil in American shales that all the oil produced in the whole world in the entire history of the industry is only a drop in the bucket in comparison with the supply the rocks offer us.



Photograph from U. S. Geological Survey

A MOUNTAIN CONTAINING MILLIONS OF TONS OF RICH OIL ROCK AT THE VERY DOOR OF TRANSPORTATION: MOUNT CALLAHAN, IN THE GRAND RIVER VALLEY, COLORADO

The immensity of the coal beds of America is overpowering, and yet they represent but a small percentage of the coal originally laid down. Between the glaciers that ground out billions of tons and the crust-crumpling processes of the earth that buried other billions of tons, great as is the amount of coal left, it is only an insignificant share of the original deposits. But though most of our coal was taken from us before we came upon the earth, some of it comes back to us in one shape or another. Petroleum is one of its proxies; oil-bearing rock is another.

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success for the industry in the United States. Not only is the oil content of the American deposit larger than that of the Scotch—in some cases more than three times as large—but the American rock can be mined more cheaply.

The Scotch shales lie far below the surface and must be mined by hand and hoisted through shafts like coal or hauled up inclines. Most of the Rocky Mountain shale lies from a few feet to 2,500 feet above the valley floors and much of it can be mined in a wholesale manner by steam-shovels and lowered by gravity to the reducing plants.

OIL FORMERLY DISTILLED FROM SHALE IN PENNSYLVANIA AND UTAH

The Scotch shales occur in irregular beds which here and there thin out and have been thrown into geologic faults and folds that greatly increase the cost of mining. The western shales, on the other hand, are more uniform in thickness and lie in a horizontal position. Despite their handicaps, the Scotch deposits are worked at a large profit, yet their average content of oil is only about 25 gallons to the ton, whereas vast quantities of easily mined American shales that lie in benches 6 to 10 feet thick will average perhaps a hundred per cent more oil.

Oil-shale distillation is not new in the United States; yet it is doubtful if there are many people alive who remember anything about the earlier industry. Before petroleum was discovered in Pennsylvania, about 50 small companies in the eastern United States were crudely distilling oil from shales; but after subterranean pools were discovered these companies went out of business.

Long ago the Mormons also distilled oil from shale near Juab, Utah, where the ruins of an old still can yet be seen. We are now about to return to this discarded industry and produce hundreds of millions of barrels of oil where formerly the output was comparable to the production of oil from sperm whales.

AMERICA'S IMMENSE MINERAL WEALTH

The discovery of these vast deposits of oil-bearing rock in the United States, the petroleum content of which can be estimated in nothing less than hundreds of billions of barrels, is one more evidence of the abounding wealth of the North American Continent. No sooner does one of our resources show limitations in production and the pessimists begin to cry, "What shall we do when our reserve is gone?" than immense additional deposits or satisfactory substitutes are discovered.

During the last few years petroleum, with its most valuable constituent, gasoline, has become one of our most vital resources, so than even the most cheerful optimist might well begin to question the immediate future prospects of the industry; but with thousands of square miles of rock lying above ground, within sight of trunk-line railroads and constituting an unfailing oil reservoir, we can feel assured of a supply of gasoline for many generations to come.

The United States is indeed a country blessed by a generous Providence. Germany, to supplement its stock of petroleum and gasoline, laboriously raises potatoes from which to distil fuel alcohol; but here in America there are mountains of oil rock which can be blasted and steam-shoveled and transported by gravity to great retorts which will turn out oil and fertilizer in limitless quantities.

The production of oil in this country, instead of decreasing, will continue to grow; it will even, because of the shale resource, greatly increase its present immense output of 340,000,000 barrels a year and will keep pace with the enormously increasing demand. No one may be bold enough to fortell what tremendous figure of production may be reached within the next ten years.

SHOPPING ABROAD FOR OUR ARMY IN FRANCE

By Herbert Corey

FOUR hundred shiploads of things the American Army needs in France have been bought in Europe.

I know of no more blunt and uncompromising way of beginning this story of a big job. It lacks color and voltage. It really should be illustrated by a diagram showing a procession of four hundred tall ships sailing into a port in France, each loaded down to the captain's quarters, while a fleet of toothless U-boats gives way to *furor Teutonicus* on the side lines. That would bring home to the reader what this achievement of the Purchasing Board in France really amounts to.

Each ton bought in Europe lessens by 2,000 pounds the strain on the tonnage line that connects the American Expeditionary Force with its home base. One might go into the dollar feature of the situation and show that each ship will cost the American Government not less than $10,000 a day, and that they will average 60 days to the round trip; but that phase is relatively unimportant. The essential point is that an enormous ocean shipment, with its attendant risks and delays, was avoided in this way.

SHORTAGES IN ALL DEPARTMENTS EXCEPT THAT OF COURAGE

The 400 shiploads only include the material bought by the Army Purchasing Board in France. A huge quantity of other goods has been bought by the commanding officers of units, these ranging from the day's rations to footwear and ready-made huts. Such purchases, however, are of the hand-to-mouth order and only satisfy the moment's needs. The greater purchase may be charged to capital account. The goods were needed for permanent equipment. They are the shelves and counters needed for Uncle Sam's new business abroad.

Every one now knows the conditions under which the American army began operations in Europe. Some thousands of men had been hastily gathered together, herded on steamers, and pelted off to France. Probably every one knows that, thanks to our failure to take out insurance before our house caught fire, this first expeditionary force only outwardly resembled an army. Seventy-five per cent of the men were rookies; some of them took their first steps before a drill sergeant on board ship. The bureaucratic chair-fillers at Washington, who used to send men to Manila wearing the clothes designed for blizzardly afternoons on Skagway Pass, were living up to their own best worst. There were shortages in every department except that of courage.

In the United States every one became busy—and talkative—at once. The columns of good news about things that were sure to take place, if nothing happened, must have sent thrills down the backbone of every good American. In France, General Pershing had no time for prognostication and hurrah.

Persons who think they know commanding generals who have had harder tasks than Pershing in this war are invited to name their candidates. He was not only responsible for those preliminary arrangements of a purely military character, which will lead to victory later on, but he was obliged to create overnight a huge business organization. He became the head of an enterprise that could put the Standard Oil octopus in its pocket and never feel it squirm.

SOME OF THE DIFFICULTIES OF THE SITUATION

The American army is 3,000 water miles away from its home base, in a country that is increasingly feeling the strain of more than three years of war. The number of Americans in France was added to each week.

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CANNED GOODS ARE A STAPLE OF THE AMERICAN SOLDIER'S DIETARY IN FRANCE

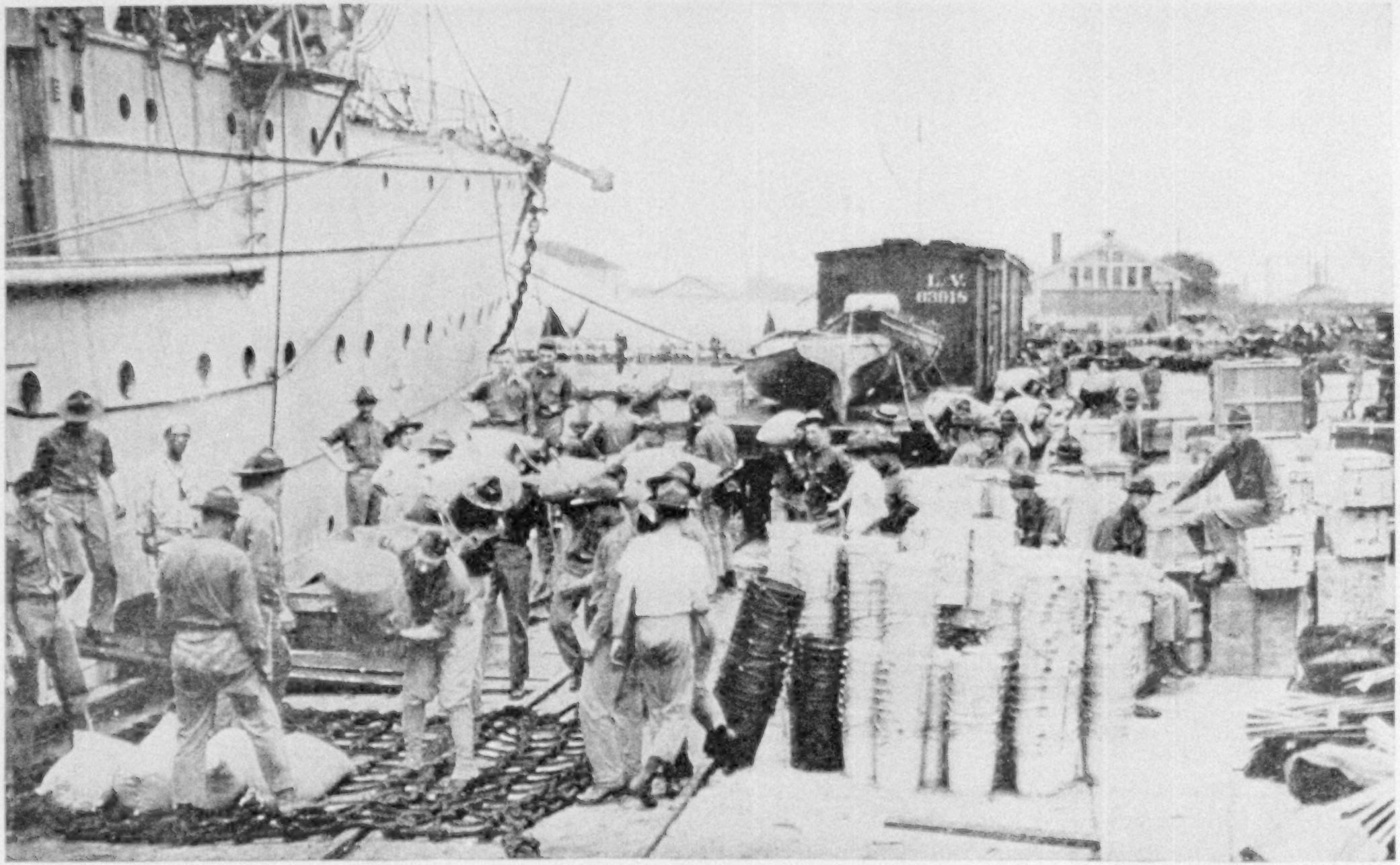
"But 'airtights' take up a frightful lot of space on shipboard, and besides, there is plenty of fruit to be had in France. To bring American canned goods to a country where every peasant makes a pet of a pear tree is like carrying coals to Newcastle. So the tin is to be brought over in sheets and made into cans in French shops, and next summer the farm women of France will put up canned goods for American soldiers."

With that growth of the army the daily needs for clothing and food grew in proportion. Reserves must be built up to provide against possible hard times ahead. Artillery must be furnished, for Uncle Sam reacted with a jerk to the discovery that the squirrel rifle of our daddies is no longer useful, there being few squirrels in France. Transportation must be furnished on an unprecedented scale. New railroads must be built and equipped and old railroads furbished up. Three-ton camions take the place of mules in hauling food for a modern army; but mules are also needed.

As the wants increased, so did the difficulties. U-boats are daily sunk in the editorial columns, but manage to maintain a certain liveliness on the high seas. No particular genius was required to demonstrate that every possible pound should be bought on the European side of the Atlantic, to loosen the tension on tonnage. But genius was needed in the buying, in order that America's allies should not be hampered. France and Great Britain and Italy are taking practically all the European market can supply, and their troops are fighting. It would not be good strategy to rob fighting forces to favor an army which is practically non-combatant as yet.

WHERE KITCHEN DIPLOMACY ENTERED

A matter of kitchen diplomacy entered into the problem also. The moment that American food purchases began to swell the prices in the village markets the French housewife would certainly protest. Her budgetary curve has been downward, for the most part, while the cost-line of cabbage and sugar has been steadily warping up. It would never do to allow the deep American pocket to



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LOADING A TRANSPORT WITH TROOPS AND SUPPLIES FOR FRANCE

"Every business operation is figured in tonnage terms nowadays. The great question is how the tons can be saved. Almost as soon as the Americans reached France the camp buckets and pots and kettles and pans were identified as space-wasters in shipholds. So the tin and galvanized iron are now taken over in the raw. Henceforth these minor and clangorous items will be manufactured in French workshops."

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enter into competition with her slender purse. It would neither be wise nor, as Americans say, "decent."

So a formula was worked out for the buying. It might be stated something after this fashion:

"Save tonnage today if we can pay back tomorrow; mortgage the future.

"Always give the fighting forces the first chance.

"Ladies first."

Some one suffered from a constriction of the imagination when the body that does the buying in Europe was named the Purchasing Board. It is libeled by so tame and commonplace a title. Its members make purchases, to be sure, but that is only one phase of its activities. Now and then it lapses into diplomacy. It negotiates with European labor and adjusts the American machines and ways of doing things to continental men and women. It is in the manufacturing business. It is turning over every shop in neutral Europe in search of raw material. And it all began in the mildest way possible.

GENERAL PERSHING'S BIG TASK

General Pershing began it, of course, for in the army all things begin and end with him. One reason why his job makes such a tremendous appeal to the imagination is that it is this sort of a job. He is not only creating an enormous business organization, but he is catching the men to run it. Sometimes he does not catch the right man, and then he has to take a few minutes off to catch the wrong man and fire him. But an organization is being created. When it gets on its feet it will stand comparison with any organization in the world. It would be folly to say that it can stand alone today.

"I must have coal," he told the man who is today the chief purchasing agent. "Go out and buy it."

I have promised the chief purchasing agent that I will not use his name, but it is only fair—to the army—to say that he was the head of a great bank in a great mid-western city. He was a business man, too, of the sort who is not afraid either of money or men. When the United States went to war he volunteered. He is still, praise be, a business man.

When he came into Pershing's office he was probably told to sit down and have a cigar, and asked if he had seen any U-boats on the way over, that being considered a neat conversational opening in France nowadays, and before he could answer he was told that the American army needed coal and that it was up to him to get it.

HOW THE PURCHASING OFFICER ACHIEVES RESULTS

Well, he got the coal. But before he got it he negotiated with two European governments and the heads of some European labor. He had to find a way to have ships commandeered, not having any handy way to commandeer the ships himself. There was even talk of reopening some of the coal mines that France has temporarily abandoned on the central plateau because of a lack of labor, but that plan was given up for various reasons.

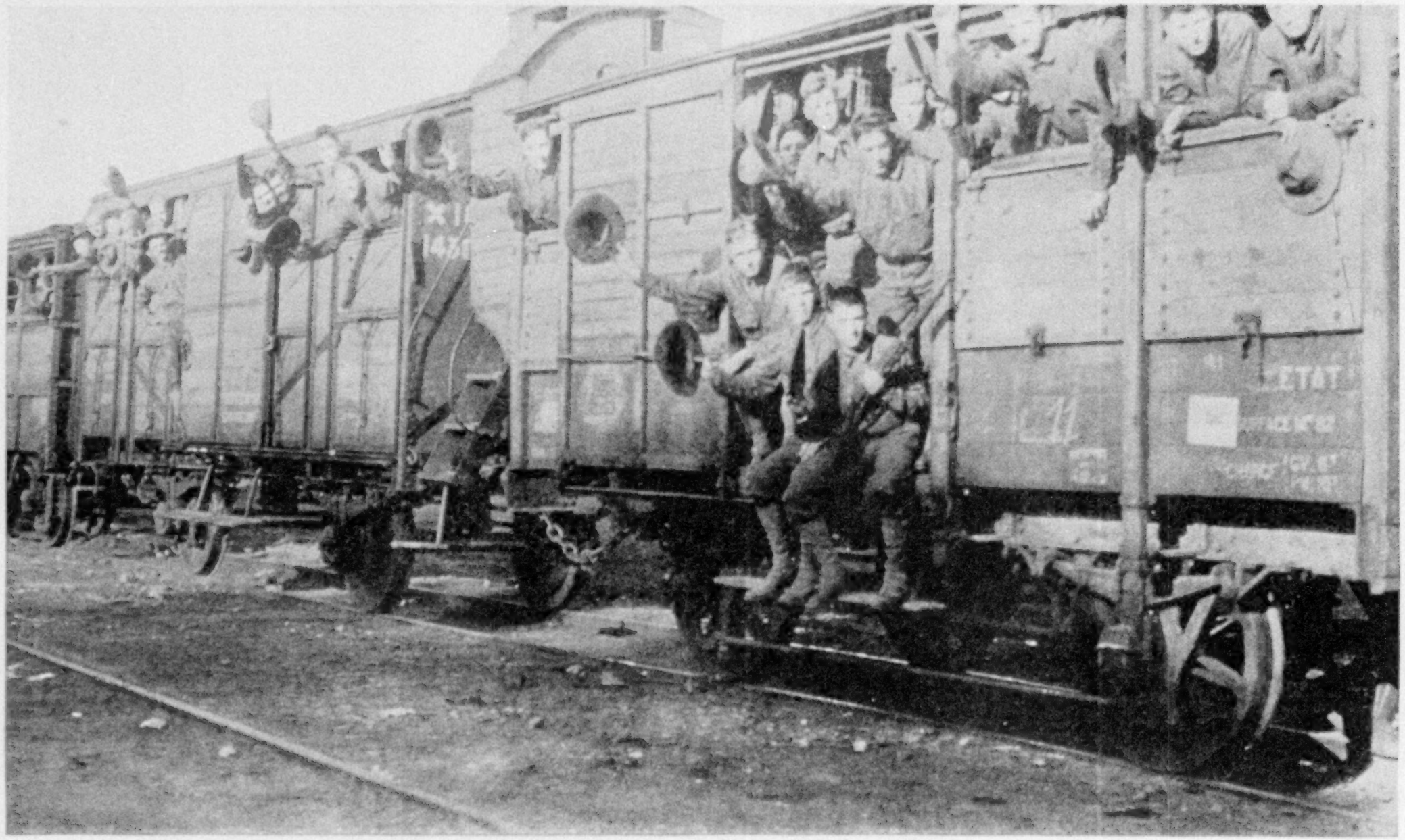
The whole secret of the job was that the American army *had* to have coal. At the moment there were 6,000 tons on hand; 10,000 tons were owing to the French Government; there was none in sight, and winter was coming on. That was a standard condition in all lines during the first days of the American activity in France.

The chief purchasing officer and his assistants got the things needed because they know how to hustle. I was in his office one day when a major, whose name and millions have been a Sunday feature in New York for twenty years, came in. The outlines of the feature have not changed materially. They consist mostly of dollars.

"I'm out of a job," said the major.

"Go to French headquarters," said the chief purchasing officer, "and get some stuff out of storage."

Before the major was out of the room the stenographer was telegraphing headquarters that the appointment of Major Money as liaison officer at French headquarters was desired. The appointment came back by wire before the major got to French headquarters. That is the sort



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U. S. MARINES IN FRANCE OFF FOR TRAINING CAMP

"Railroad cars were found here and there. One would not think that so conspicuous a thing as a railroad car could be lost, but they have assuredly been found. The explanation is that France has had no men to spare for repairing cars. The derelicts had been cast away in railroad backwaters. American scouts found them and American mechanics were set to work making them over."

of speed they are showing in the Purchasing Board. The chief purchasing officer likes to hustle—and anyhow it is forced on him.

"The French expect us to hustle American fashion," said he. "They would be disappointed if we did not. What else can we do?"

EVERYTHING NEEDED AT ONCE

Everything was needed at once. Cloth for uniforms was bought in England, along with shoes and hats and blankets. France furnished cannon and tents, and pots and pans, and food. The rooky army was billeted in peasants' cottages until material for huts could be found and the huts built.

Paris was drained dry of all sorts of office material. I doubt if there is a good desk or filing cabinet or revolving chair to be found there today. The American army reached France as bare as a fish and it had to be provided for. Naturally enough, prices blew out of the chimney in this forced draft of demand. Three times the peace value was a fair price.

"I must have tents and blankets and cots for 250 men by six o'clock," was the telephone message that came to one buyer at noon one day.

"There isn't a tent nor a blanket nor a cot in town," said the buyer.

Usually that would have ended the conversation. But the man at the other end of the telephone was in earnest.

"Then 250 men will sleep in the snow tonight and cover themselves with a ditch," said he. "Don't tell me you can't get that stuff. You've got to get it."

NO ATTEMPT TO SAVE DOLLARS INSTEAD OF LIVES

He got the stuff, of course. That was General Pershing's standing order in those days. He did not attempt to save dollars at the cost of lives and worry and days. If he had tried to save money that way, he would not have been fit for his job. Little by little, order came out of the original chaos. The things that were needed before the army could set up shop in France—before it could even open the shop door—were bought at the best prices possible. Then began the work of organizing the business. The army began to plan ahead and cut out waste.

The Purchasing Board was created. It is composed of the purchasing officers of the various army departments, while the purchasing officers of the Y. M. C. A. and Red Cross have a sort of collateral relationship to the Board, for both organizations are often in the market for the things the army needs. At each meeting the purchasing officers pool their discoveries and their needs.

Scouts have ransacked France and England and neutral Europe for deposits of raw material. The list of needs is made up in each department for three months ahead.

"Seven departments want 40,000 fish-hooks each," it might read, it being understood that in verity no department wants fish-hooks. "There are 192,000 fish-hooks available at the following prices."

WORKING IN CONJUNCTION WITH THE FRENCH MILITARY MISSION

The need being imperative, the purchasing officers of the seven departments are given permission by the Board to buy the fish-hooks. But before the buying is done, the need and the prices are placed before the French Military Mission, which works in conjunction with the Purchasing Board. It is conceivable that the French army needs fish-hooks, or army shoes, or rubber blankets, or whatever the item may be. It has the first call on the material available, but its officers have shown themselves extraordinarily helpful and generous. They have always pruned their own wants to the final hair rather than pinch the Americans.

"I cannot say enough as to the spirit in which we have been met," said the chief purchasing officer. "The French have placed their entire organization at our disposal and have opened all their records. Far from asking them to do more, our constant feeling is that we are ungenerous in permitting them to do so much."

The French Mission also passes upon the prices the American officers are willing to pay. In some instances purchases have not been made because the price was exorbitant. Throughout all these deal-

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AN AMERICAN RAILWAY STATION NESTLED IN THE HILLS OF FRANCE

Every car that is put on wheels in France means a saving of precious tonnage over the ocean. Eight hundred castaway Belgian locomotives have been rescued from the junk yards by the American Purchasing Board and are now being rebuilt by Belgian workmen.

ings the spirit of mutual helpfulness is evident. Sometimes the French Mission has been able to secure better prices than the American officers have found, and sometimes they have revealed stocks of material the Americans had been unable to find. When the consent of the French Mission is obtained the purchase is made.

In the first days of the American expedition in France purchases were made in a scattering fashion. Then it became obvious that if only a few tents were needed at the moment, the day would come when tents by the thousand would be necessary. Therefore the man who found tents for sale—or anything else—bought all he could find if the price was right. Nowadays system has come into its own. The list of requirements for the army is made up now for three months ahead, on the basis of requisitions furnished by the officers commanding the active units. That is known as the "uniform" equipment. It is apparent that a unit of 25,000 men will always need certain things. It is equally apparent that there is no close relation between 25,000 railroad ties and 25,000 men. Sometimes the "exceptional" equipment comes into play.

RAILROADS PLAYING A MAJOR RÔLE

"We must build railroads," the Purchasing Board was told by headquarters. "Get the material."

In the good old days railroads were not of the major importance in warfare that they are today. The Germans upset the old rules of transportation. Early in the war they began to string little quarry roads behind the western front. The French followed suit. When the British began their Somme offensive, in 1916, they had laid more than 3,000 miles of road, standard and narrow gauge, behind their comparatively narrow front. The American army's railroad needs will also be great. The existing roads from the water bases must be reconstructed to take care of the heavy traffic anticipated. Preparations must be made for the feeder lines behind the front, when that front becomes an actuality.

The American army cannot take cars and engines and cross-ties from its allies. "Scout for them" was the order of the purchasing officer.

It is at this point that the American business men who have become officers in the American army began to show themselves particularly useful. The chief purchasing officer once said a pertinent thing: "Put a captain of industry," said he, "in a uniform of a captain of the army and you have a combination that gets results." These men are familiar with all phases of American and European business. They know where things may be found and how to find them and how to buy them. They are used to doing big things in a big way.

PREDICAMENTS OF SPAIN AND SWITZERLAND

So the scouting for railroad material was done by experts. Little jags of steel rails were found that had been forgotten. There were disused patches of railroads and sidings that furnished a handful each. Wanderers in the back blocks of Switzerland and Spain and Portugal found railroad ties. Portugal was ready enough to sell—at a price—for she is an ally, but at this point the Purchasing Board entered the realms of diplomacy. Switzerland and Spain were likewise willing to sell—but for a consideration over and above the purchase price.

These countries had an "internal" situation to consider. Señor Garcia Price, Prime Minister of Spain, in a recently quoted interview, declared that if the United States did not furnish cotton to the Barcelona mills hundreds of thousands of persons would be thrown out of work. A crisis cloud is forever banking up on the edge of the Spanish horizon. There has not been the least concealment of a revolutionary party in Spain, or that an enforced stoppage of work would naturally strengthen the forces of discontent.

In similar fashion Switzerland is set between a very ravenous devil and a particularly blue sea.

On the one side she must buy coal and iron ore from Germany, or her people would freeze in the winter and her industries would wither and blow away. Before Germany will deliver these and

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other things that the Swiss must have, she extorts her own terms. Germany recently compelled certain Swiss banks, unofficially, to take a part of a war loan, for example, and the Swiss food reserves are continually tapped by her.

It would be impracticable for Switzerland to turn over to Germany the foods she receives from the Allies, but Swiss cheese is about the scarcest thing in Switzerland. The Allies appreciate the position in which Switzerland is placed and have tried to be as generous as possible. Most of her food-stuffs come from France and Great Britain today.

I am not in a position to go more deeply into the course of the diplomatic negotiations which the Purchasing Board entered upon. But the American railroads in France will be set in part upon 25,000 ties bought in Switzerland, while 20,000 sleek Spanish mules have braved their way across the mountains to enter Uncle Sam's service. Contracts have been let to Swiss manufacturers to make certain things for the Americans, too, and there a further dalliance with diplomacy was needed.

The raw material must be furnished the Swiss, for they did not have it. That was agreed to. Then Germany became aware of the arrangement. Germany furnishes a greater part of the coal to Switzerland. The mere suggestion that an ounce of her coal should be used to fire boilers to make steam to run lathes to shape shells—or other things—for the wholly to be looked-down-upon Americans sent the Wilhelmstrasse into a tremble. So the Purchasing Board had to arrange that coal should be furnished these manufacturers.

RAILROAD CARS LOST AND FOUND

Railroad cars were found here and there. One would not think that so conspicuous an article as a railroad car could be lost, but they have assuredly been found. The explanation is that France has had no men to spare for repairing cars, except when the repairs were vitally necessary. Little by little, derelicts have been cast away in railroad backwaters. They still had the outward aspect of cars, and there were wheels under them, but that was about all that could be said. The American scouts, prying into all stray corners, found them, and workmen were found—some of them belong to American engineer regiments—and the cars were made over again. Every car that could be put on wheels in France meant a saving of precious tonnage over the ocean. Then a discovery that might be called sensational was reported to the Board.

"Did you know," a scout asked, "that there are 800 unused Belgian locomotives in France?"

ALL THAT WAS LEFT OF BELGIUM

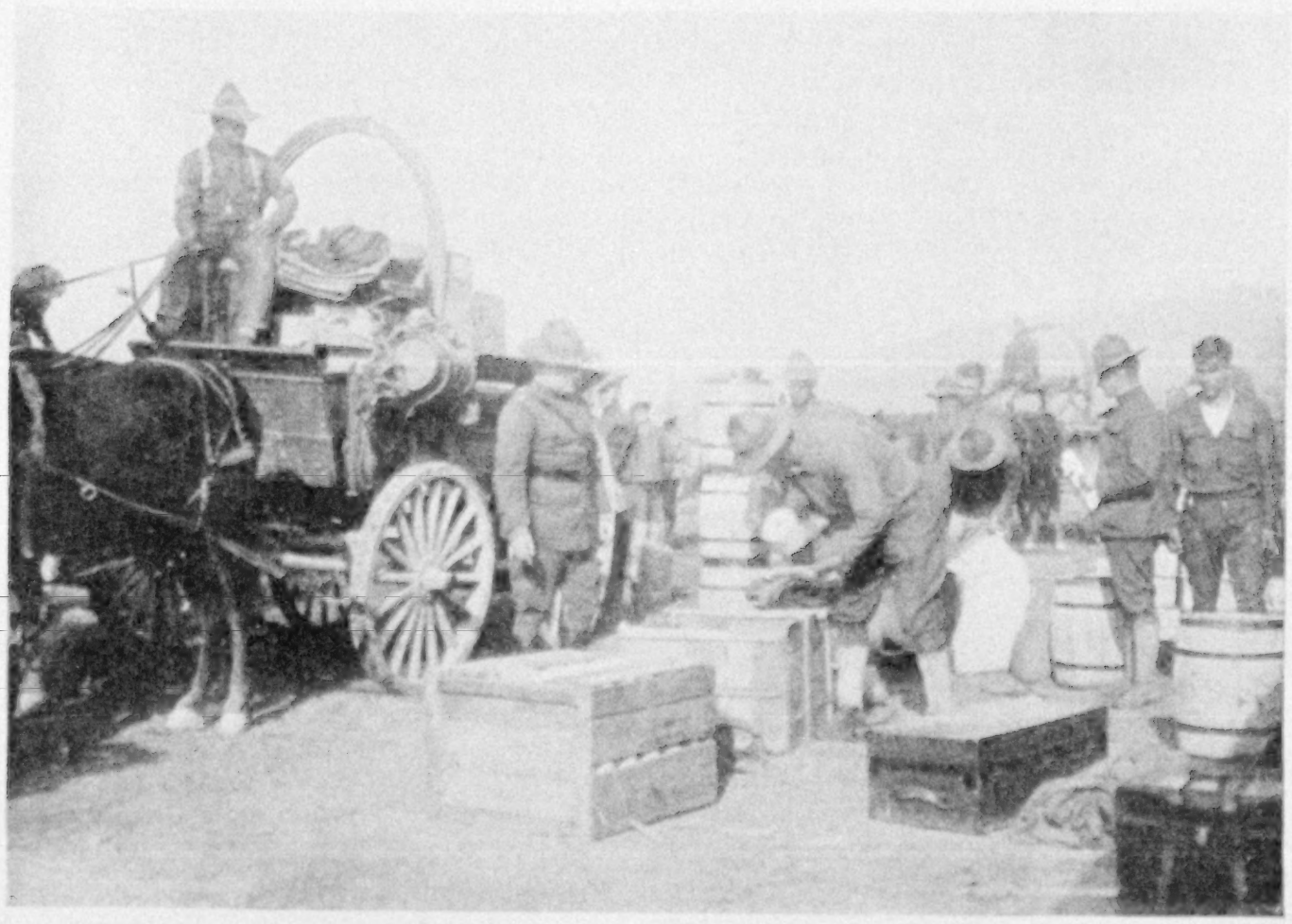
The tale of the locomotives is a tag to the tragic story of Belgium. When the Germans invaded that little State, the dazed people saved what they could. Most of the rolling stock was lost, but the Belgians managed to run 1,900 engines over the border into the safe land of France. The needs of France and England were paramount in those days, and 1,100 engines were turned over to the armies for service. Naturally enough, only the best were taken. The 800 that were left were rusted and shabby, but they were precious in the eyes of their Belgian owners.

"They are all we have left," they said, "all that is left to us of Belgium."

Once more the purchasing officer became a diplomat. The Belgians had been ruled by sentiment. For the moment they were not thinking of the practical side of the question. The 800 old engines were a symbol in their eyes. They were useless as they were. Weeds were growing through their fire-boxes. Many had been sacked of spare parts that better engines might be rebuilt. They were incredibly and pathetically decrepit, but they were all that was left of Belgium.

"We're trying to help you, you know," said the purchasing officer. "Let's all pull together."

So he got the engines. Before they could be made useful they must be rebuilt. Belgian workmen were available for the rebuilding, and there are no better workmen in Europe; but they were empty-handed. The Purchasing Board's scouts patiently ransacked France and



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ISSUING SUPPLIES TO TROOPS IN FRANCE

"The American army is 3,000 water miles away from its home base, in a country that is increasingly feeling the strain of more than three years of war"

England, hole and corner, until enough machine tools were found for the operation. France was practically cleaned of her spare machine tools, but somewhere in France the rebuilding process will be finished by the time the Belgian locomotives are finished.

In England the Board's scouts work with the government. Manufacturing is the great business of the country. The British are familiar with it. Early in the war they took steps to earmark all stocks of raw material, so that when the Board wants a given thing it has but to say so.

The permanent under-secretary, in charge of three-inch screws, has but to turn to his index to state whether he can furnish the screws wanted and when and how many and where. It is different in France. The French are individual to their heels. Instead of one large manufactory, they prefer many small manufactories for a given output. Each factory stands on its own bottom. Each has its own supplies.

Further, France has been so busy fighting since the beginning of the war that she has not had time to take governmental charge of her deposits of raw material. Her administrative energies have been devoted to getting every valid man in line and keeping him there. Coincidentally, her manufacturers have been able to keep that line nourished with every form of supply an army needs, but it has been largely by private enterprise.

The individual manufacturer has found his materials where he could and the women have done the work. It is the women who will do the work when the American Army's Purchasing Board goes into the manufacturing business this year.

ARMY'S BUSINESS OPERATIONS FIGURED IN TONNAGE

Every business operation of the army is figured in tonnage terms nowadays. The great question is how the tons can be saved. Almost as soon as the Amer-

icans reached France the camp buckets and kettles and pots and pans were identified by some observer as space-wasters in shipholds. Pots that will "stack" were bearable, but too many kettles will not stack. So the tin and galvanized iron and what-not needed were brought over in the raw and contracts given to any small workshop factories in France to manufacture these minor and clangorous items. The idea proved sound. France is short of labor, but there are still women and youngsters and exempts to be had. The Purchasing Board began to ask itself:

"Why not make more things?"

Canned goods are a staple of the American soldier's dietary. He likes to buy a can of peaches and a can of condensed cream and pour the milk onto the peaches and fragrantly eat the combination. All his life he has been used to canned goods. Every company canteen has handled "airtights." But they take up a frightful lot of space on shipboard, and besides there is plenty of fruit to be had in France. To bring American canned goods to a country where each peasant makes a pet of a pear tree is like carrying coals to Newcastle.

FRENCH WOMEN TO CAN FOR AMERICAN SOLDIERS

So the tin is to be brought over in sheets and made into cans in French shops. Next summer the farm women of France will be supplied with tin cans and sugar and contracts, and will furnish what part of the canned goods for the American army's consumption that may be possible. The French woman is particularly expert at jam-making, and next winter the American boys will have jam on their white bread. There is an annex to this story, too. For some reason France has never taken kindly to canning fruit, although, oddly enough, quantities of American canned fruits have been sold in France. It is believed this practical demonstration on a large scale may mean the creation of a new industry.

If I tell the story of another of the Board's infinite number of manufacturing activities, it is only because it even better illustrates the care that is being taken to cut down tonnage. Chocolate is a standard item with every soldier. When possible, chocolate candy is put on sale in the canteens, and when that is not practicable chocolate bars are offered him. Cocoa beans, however, do not originate in the United States, and there is a demonstrable waste of time and space in shipping them first to America and then combining their essential oils with sugar and sending the resultant goody to France; so that now the cocoa beans are shipped straight to France from the place of origin and the sugar sent over from the United States. French manufacturers do the rest. Likewise the sweet, crisp biscuits the boys like are no longer being imported. The sugar and flour are brought in and turned over to French bakers.

American splints are being made in France on the same plan. In pursuance of the army policy of getting ready for the worst, an enormous supply of splints was considered necessary. Splints are awkward things to pack. They come in queer, unusual forms, and must be carefully boxed, because they are very fragile. After the standard forms had been decided on by the Army Splint Board, which is in charge of this item, the order was turned over to the Red Cross, which had promised to supply them. Acting in perfect harmony with the Purchasing Board, 100 tons of the needed metal were brought to France and the splints were made. They would have taken up not less than 1,000 tons of shipboard space if shipped in the completed form.

MEN WHOSE HEARTS ARE IN THEIR WORK

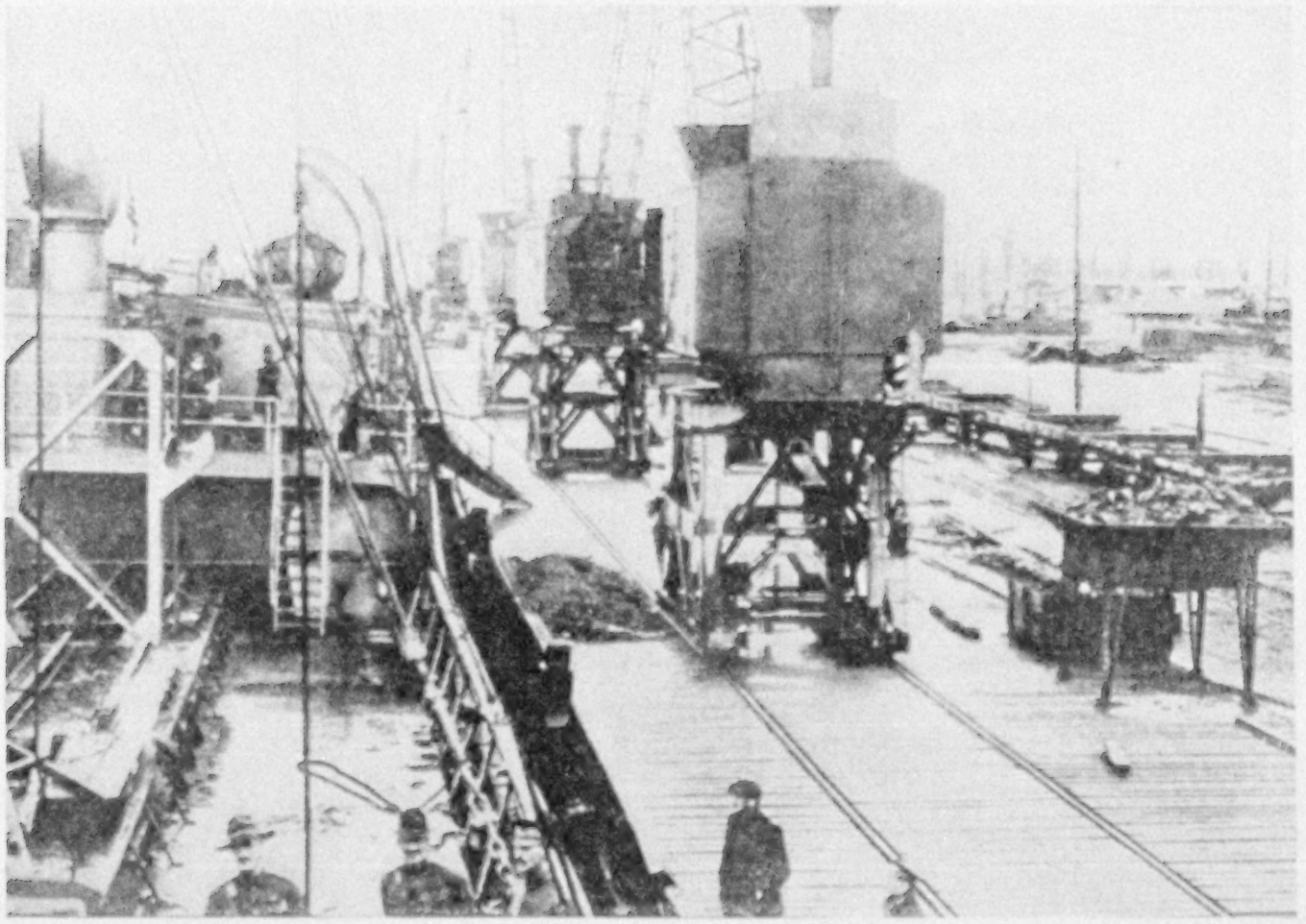
When an army requisition has passed through the Purchasing Board's hands, the terms of the equation are about as follows:

"We need so many tons;

"We can buy so many tons in France;

"We can import so many tons."

Then general headquarters passes on the order. General headquarters is the final arbiter on all things. Somewhere in that mysterious region is a sheet showing the number of ships which are to sail from the United States and the tonnage space available. There is always a need for a great deal more space than can pos-



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STEAM CRANES USED IN UNLOADING AMERICAN SUPPLY SHIPS AT A FRENCH PORT

The American army's Purchasing Board in France makes purchases, negotiates with European labor, adjusts American machines and ways of doing things to continental men and women—all to relieve allied shipping and French docks of as much of the transportation burdens as possible.

sibly be secured, so that general headquarters goes over the list of needs with a pruning knife. It is interesting—and tragic—to listen to the men whose departments have been pruned. They act as if their entire future lives had been spoiled. They are the sort of men General Pershing has on this sort of a job. Their hearts are in their work.

Once the wants are compressed to the dimensions of the can-gets, the orders are sent to the United States for the material that is to be shipped. On the French side the General Purchasing Board, through its members, is hurrying about, getting what can be got. The Board, as a Board, makes no purchases. It is only a directing mechanism—a sort of a congress of prices and supplies. The competition between the different departments of the United States Army has been disposed of in the session of the Board in which each man has placed his cards upon the table; but there is still the competition with the French and British governments to be guarded against.

This guard is absolute, where goods are to be bought in Great Britain. There the British Government does the buying and the United States Army settles for the goods bought; otherwise no goods could get out of England. Not even a Christmas card could be sent to France last winter without a special license for the sending. In the neutral countries of Europe a Franco-American Purchasing Board handles all such purchases, except in cases where the Inter-Allied Purchasing Board assumes the right.

It is too early as yet to say what will be the full scope of the Board's manufacturing activities in France. However, apart from the question of raw material, it must be limited by the labor and facili-

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ties available. The greater part of the present manufacturing potentialities of France are already absorbed by the needs of the government and the civilian population. It would be a comparatively easy matter to enlarge the factories now in being, or build more, and equip them with American machinery, but the labor is not at hand.

"WHY NOT IMPORT AMERICAN LABOR?"

"Why not import Americans?" I asked.

That has been carefully considered, it appears, but the idea is not likely to be put in effect on a large scale. Every imported American must be fed and clothed and provided for in France. Use will be made of all the labor available on the ground before the Americans will be brought over. The Purchasing Board once had under consideration bringing in labor from Greece and Spain, but diplomatic considerations intervened. This is a story that may never be told.

Offhand one would think that many of the things now being bought would outlast the war. But things do not last in war. Clothing wears out and tents go to pieces and mules die and cars get shell-shock. The chief purchasing officer thought that the 1,804,000 tons which were purchased in Europe in six months (the total must run to more than 2,000,000 by the time this article appears) would prove to be only a beginning. As the army increases in France, so will the purchases. The time will come, of course, when the buying will be largely confined to the raw materials available, but that buying will account for practically every pound the armies of the other allies do not take.

To the outsider the impressive feature of the organization, apart from the dent that is being put in the U-boat totals by this organized and systematic development of assets at hand, is the perfect teamwork that prevails. Some members of the purchasing department are Regular Army officers; others are business men who have never seen an army officer before except in the Memorial Day parade. Their methods and training and outlook are entirely different; yet they have dovetailed together perfectly.

The complexity of their tasks may be surmised from the fact that the first two requisitions passed on totaled up more than 3,000 articles, but competition between departments and governments on prices had been practically eliminated. These men have been suddenly called upon to handle a business ten times as large as that of United States Steel, and they have handled it. Some have made good and some have failed; but most have made good.

The chief purchasing officer remarked, incidentally, that in his six months at the job he had not found one case of dishonesty on the part of an army officer; but he did not think that remarkable.

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6 McCormack as Sir Edgar in Lucia
7 Gluck as Nedda in Pagliacci
8 Scotti as Scarpia in Tosca
9 Homer as Amneris in Aida
10 Ruffo as Rigoletto
11 Tetrazzini as Lakme
12 Garrison as Queen of Night in Magic Flute
13 Martinelli as Mario in Tosca
14 Calvé as Carmen
15 Journet as Mephistopheles in Faust
16 Aida as Desdemona in Othello
17 Bonci as Martha in Boris Godounow
18 De Luca as Figaro in Barber of Seville
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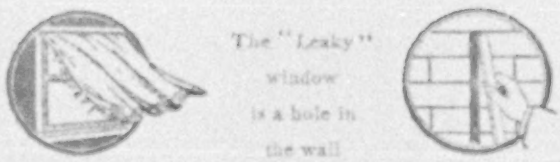

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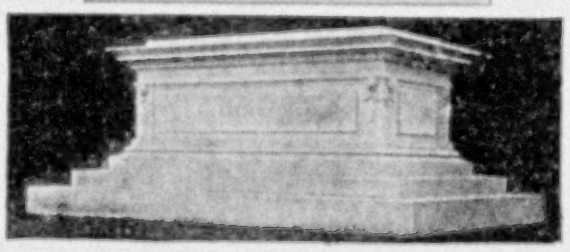

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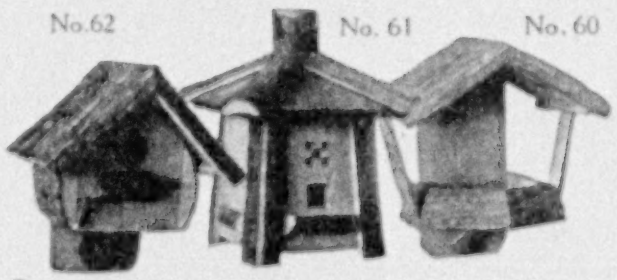

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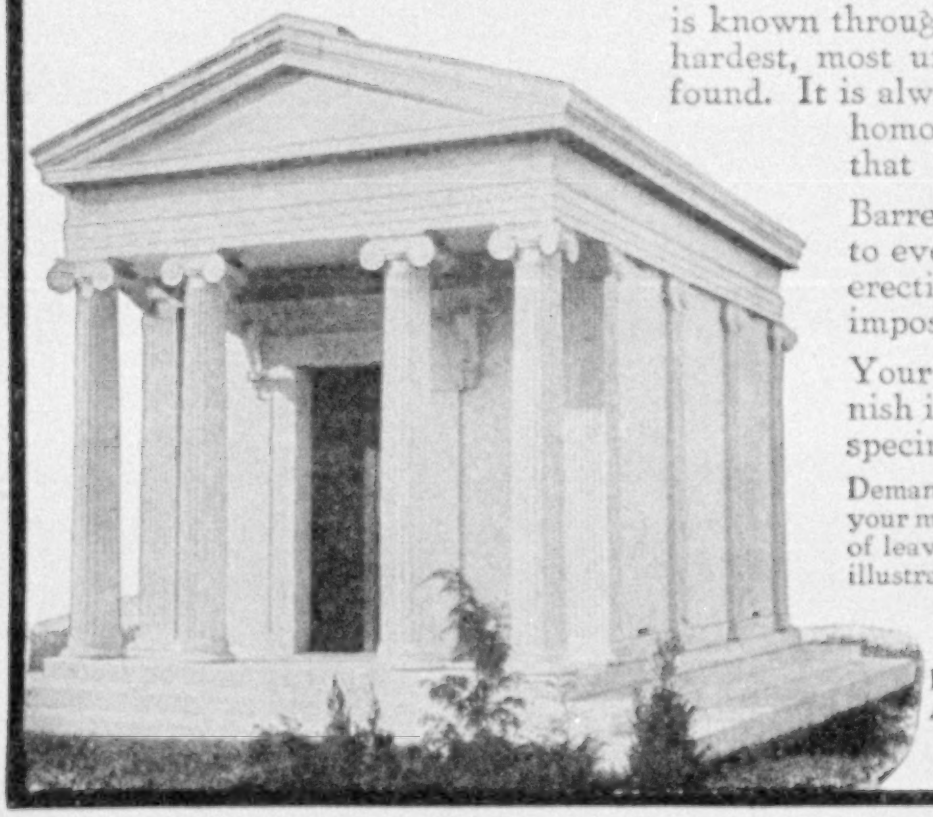

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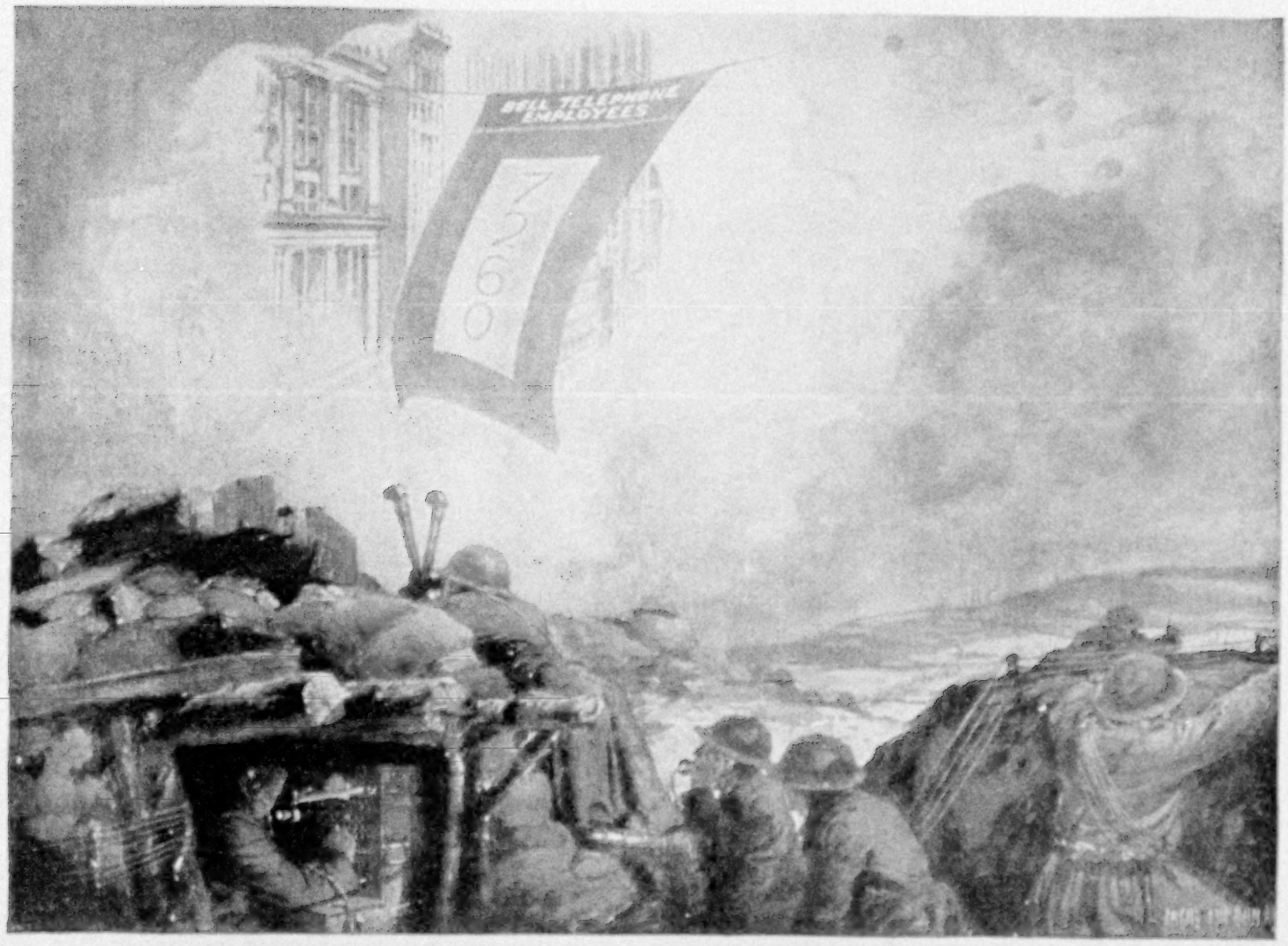

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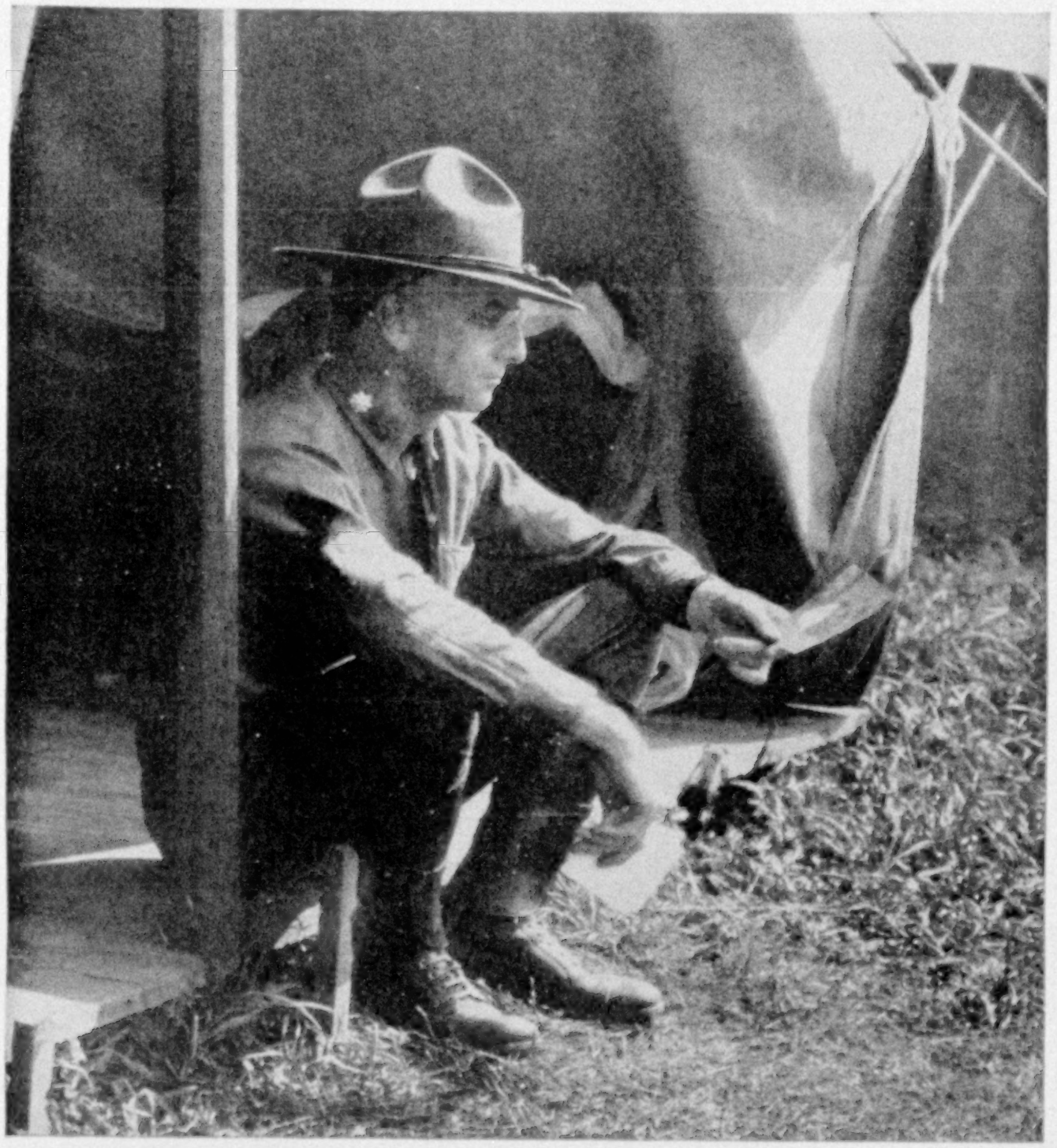

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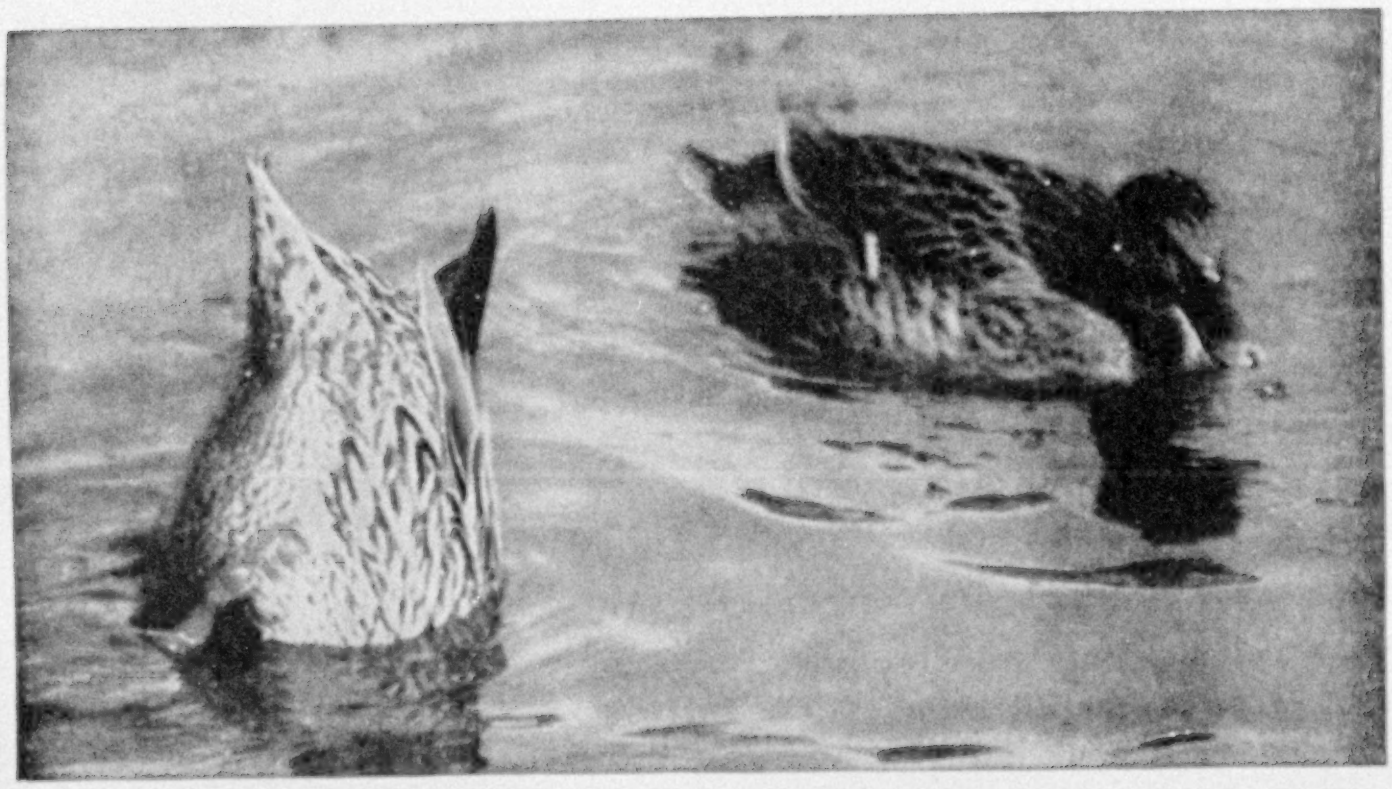

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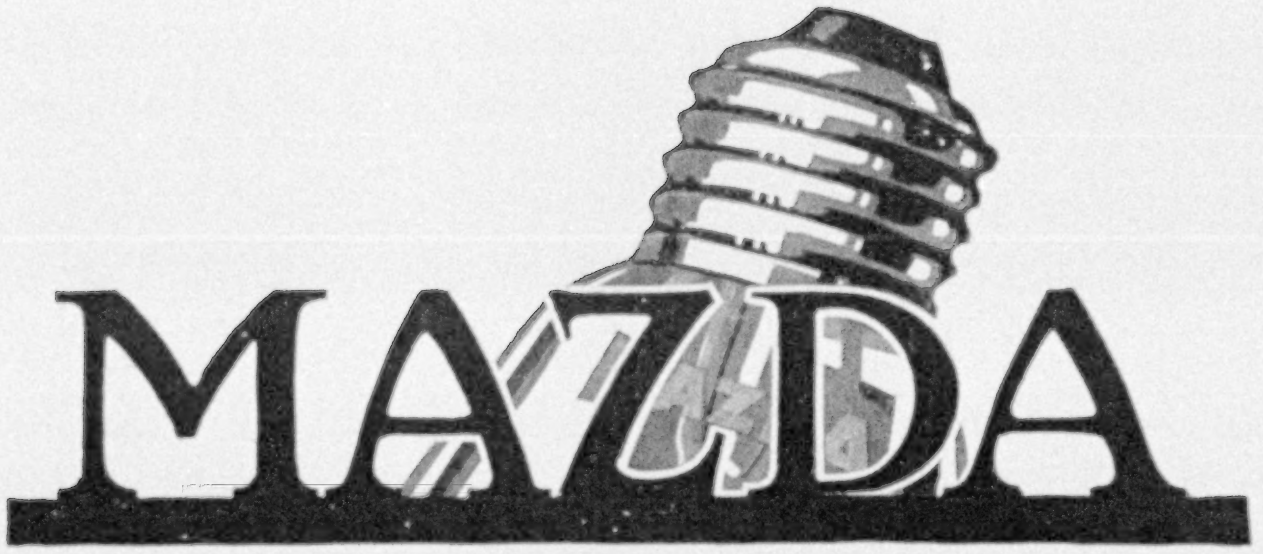

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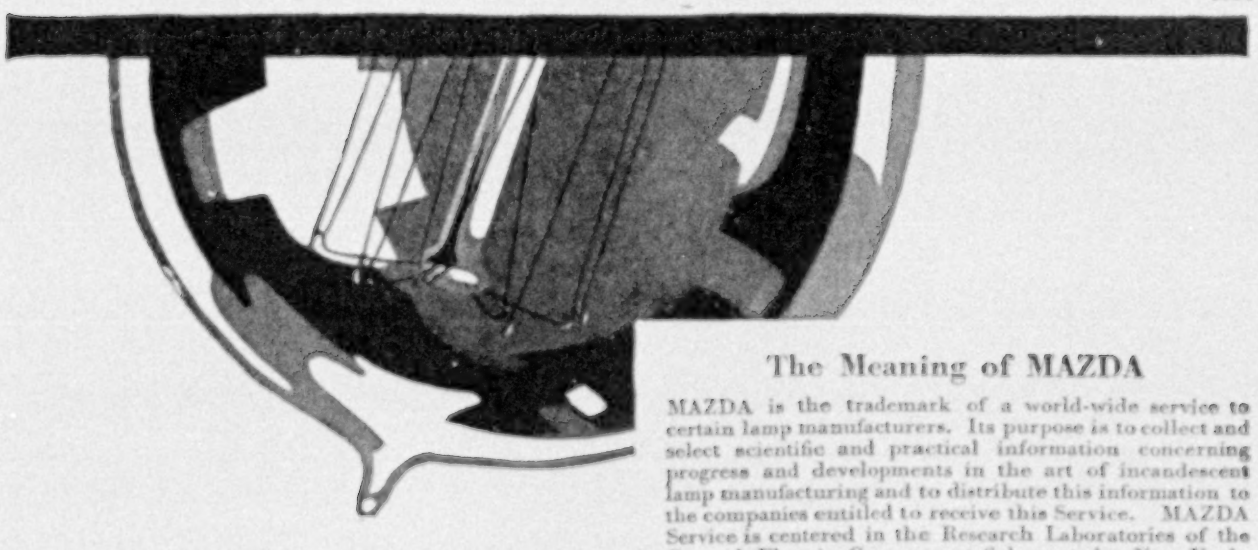

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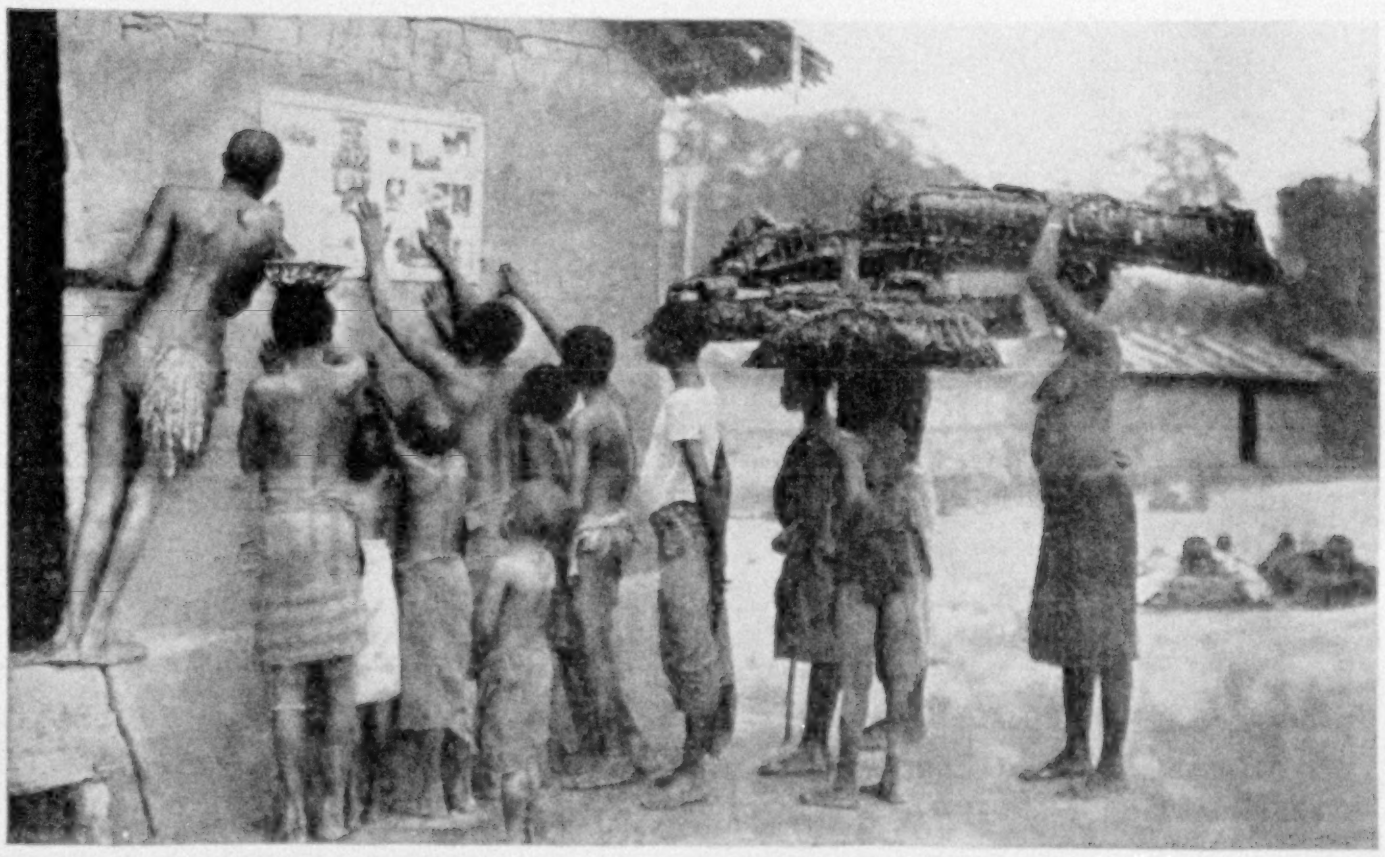

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Facts from the Fuel Administration

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In 1916 approximately six-hundred-million tons of coal were mined in this country. By working under great pressure during 1917, and in spite of shortage in labor, the mines increased this record output of 1916 by fifty-million tons. The nation, however, is still short of the amount required for the conduct of the war by fifty-million tons. This coal cannot be mined. *It must be saved.*

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Coaling our navy under war conditions.

Producing large quantities of guns, gun carriages, small arms, ammunition, explosives, aeroplanes and other army and navy supplies.

Building ships to replace those sunk by German submarines.

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A shovelful of coal saved daily in each of 15,000,000 homes means a saving of fifteen-million tons a year.

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SAVE *that extra shovelful!*

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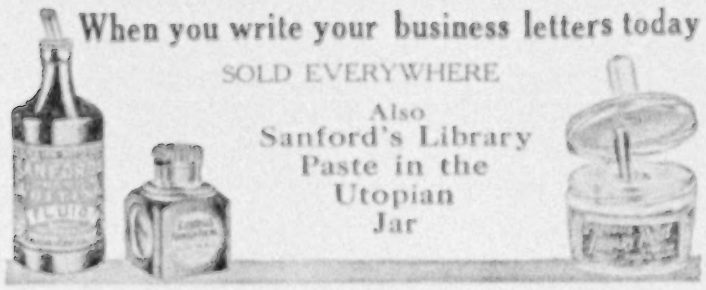

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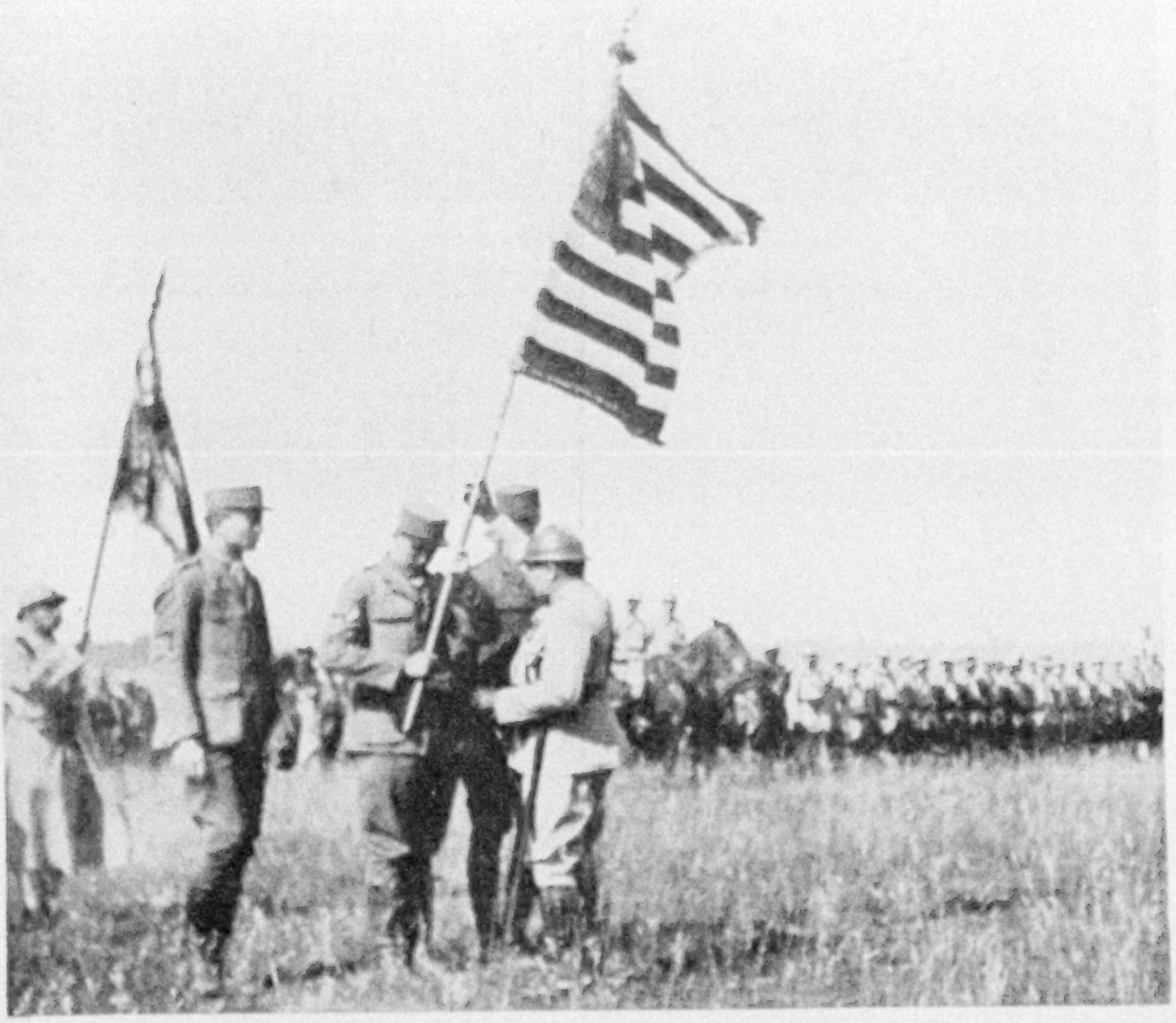

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